GOVERNMENT OF CANADA
DEPARTMENT OF ENERGY, MINES AND RESOURCES

ENGINEERING EVALUATION of FLUIDIZED BED BOILER DEMONSTRATION

at
Canadian Forces Base
Summerside, Prince Edward Island

Prepared by

MONENCO CONSULTANTS LIMITED
One St. Paul Street
St. Catharines, Ontario
Canada L2R 7J9

TITLE: ENGINEERING EVALUATION OF FLUIDIZED BED BOILER DEMONSTRATION AT
CFB SUMMERSIDE, PRINCE EDWARD ISLAND

FINAL REPORT
BY:

MONENCO CONSULTANTS LIMITED
ST. CATHARINES, ONTARIO
CANADA
Principal Author: A. Ismail, P.Eng.

Work on the project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology, Research and Technology Sector, with the support of the Coal Division, Mineral Policy Sector, both of Energy, Mines and Resources Canada.

DSS FILE NO: 14SQ.23440-5-9214
DSS CONTRACT SERIAL NO: 0SQ85-00343
CANMET PROJECT NO: 506202

MICROMEDIA

CANMET SCIENTIFIC AUTHORITY: Mr. Frank Friedrich

345pp

DATE: MARCH 1987

TABLE OF CONTENTS

PAGE

TABLE OF CONTENTS (i)
TABLE OF FIGURES (vi)

PART 1 - EXECUTIVE SUMMARY AND CONCLUSIONS

1.1 EXECUTIVE SUMMARY / RÉSUMÉ 1-1 /1-16
  110 GENERAL / GÉNÉRALITÉS 1-1 /1-16
  111 FURNACE TUBE EROSION / ÉROSION DES TUBES DE LA FOURNAISE 1-2 /1-18
  112 PLANT OPERATION / EXPLOITATION DE L'USINE 1-7 /1-22
    112.1 Fluidized Bed Systems / Systèmes de lits fluidisés 1-7 /1-23
    112.2 Ash Systems / Systèmes de cendre 1-11/1-27
    112.3 Draft System / Système d'appel d'air 1-12/1-29
    112.4 Common Systems / Système commun 1-13/1-30

1.2 CONCLUSIONS 1-15/1-32

1.3 ABBREVIATIONS 1-34

PART 2 - INTRODUCTION

2.1 BACKGROUND AND OBJECTIVES 2-1

2.2 DESCRIPTION OF "AS CONSTRUCTED" PLANT (NOV. 1982) 2-3
  221 INTRODUCTION 2-3
  222 PLANT LAYOUT 2-3

TABLE OF CONTENTS (Cont'd)

PAGE

223 MATERIALS STORAGE AND HANDLING SYSTEMS 2-6
  223.1 Coal 2-6
  223.2 Wood Chips 2-9
  223.3 Limestone 2-10
  223.4 Ash Handling 2-10
224 PLANT AUXILIARY SYSTEMS 2-11
  224.1 Steam and Condensate Systems 2-11
  224.2 Lighting-up Fuel System 2-12
225 ELECTRICAL 2-12
226 BOILER DESIGN 2-13
  226.1 Gas Path 2-13
  226.2 Boiler, Furnace and Pressure Parts 2-13
  226.3 Feed Systems for Coal, Wood and Limestone 2-16
  226.4 Carbon Recycle 2-17
  226.5 Bed Drain System 2-17
  226.6 Secondary Heat Recovery and Flue Gas Clean-up 2-18
  226.7 Bed Light-up System 2-19
227 CONTROL AND INSTRUMENTATION SYSTEMS 2-19
  227.1 Control Room 2-19
  227.2 Control Philosophy 2-20
  227.3 Fluidized Bed Boiler Controls 2-20
  227.4 Controls for Miscellaneous Equipment and Systems 2-22
  227.5 Materials Handling Systems 2-23

2.3 SOURCES OF DATA AND ACKNOWLEDGEMENTS 2-30
  231 SOURCES OF DATA 2-30
  232 ACKNOWLEDGEMENTS 2-31

TABLE OF CONTENTS (Cont'd)

PAGE

PART 3 - FURNACE TUBE EROSION

3.1 ANALYSIS OF EROSION AND THE VARIOUS REMEDIAL MEASURES ADOPTED 3-1
  311 INITIAL OPERATION AND EARLY DETECTION OF TUBE EROSION 3-1
    311.1 Initial Operation 3-1
    311.2 Early Erosion Detection 3-2
  312 CONCLUSIONS DRAWN FROM EVIDENCE AND REMEDIAL MEASURES PLANNED 3-3
    312.1 Conclusions Drawn 3-3
    312.2 Remedial Measures Planned 3-3
    312.3 Selection of Refractory 3-4
    312.4 Perimeter Nozzles 3-6
  313 EXECUTION OF THE PLANNED REMEDIAL MEASURES AND ANALYSIS OF THE RESULTS ACHIEVED 3-6
    313.1 Perimeter Nozzles Installed in FBB-2 (83/02/28 - 83/03/05) 3-6
    313.2 Lavalox Application in FBB-1 and FBB-2 3-8
    313.3 Analysis of the Physical Performance and Progressive Condition of the Lavalox Refractory 3-9
    313.4 Other Effects of the Application of Lavalox Refractory 3-13
  314 ADDITIONAL MEASURES (SHEDS) TO COUNTERACT SPECIFIC PROBLEMS ARISING FROM THE EXECUTED CHANGES 3-16
  315 EROSION OF IN-BED TUBES AND THE SUCCESS OF MEASURES TO PROTECT THEM 3-17
  316 STUDDING THE WATERWALLS 3-18

TABLE OF CONTENTS (Cont'd)

PAGE

3.2 TUBE THICKNESS MEASUREMENT PROGRAM 3-26
- 321 FREQUENCY OF TUBE THICKNESS MEASUREMENT IN RELATION TO HOURS OF OPERATION 3-26
- 322 METHODOLOGY AND THE PROBLEM OF CONSISTENT AND COMPARABLE MEASUREMENT 3-27
  - 322.1 Methodology 3-27
  - 322.2 Problem of Consistent and Comparable Measurement 3-27

3.3 TABLES OF TUBE THICKNESS AND STUD LENGTH MEASUREMENT AND CONTOUR PLOTS 3-32

PART 4 - PLANT OPERATION

4.1 FLUIDIZED BED BOILERS 4-2
  - 411.1 Ash Reinjection 4-3
  - 411.2 Stokers 4-21
  - 411.3 Furnace Components 4-27
  - 411.31 Interbed Transfer Gate 4-27
  - 411.32 Distributor Plate and Nozzles 4-29
  - 411.33 Thermocouples and Thermowells 4-37
  - 411.4 Boiler and Fluidized Bed 4-38
- 412 ASH SYSTEMS 4-40
  - 412.1 Boiler Ash 4-40
  - 412.2 Fly Ash 4-44
  - 412.3 Ash Handling System 4-47
- 413 DRAFT SYSTEM 4-48

TABLE OF CONTENTS (Cont'd)

PAGE

4.2 COMMON SYSTEMS 4-50
- 421 FUEL AND FUEL HANDLING SYSTEM 4-50
  - 421.1 Coal Sources and Characteristics 4-50
  - 421.2 Plant Coal Handling Systems 4-50
- 422 LIMESTONE AND LIMESTONE HANDLING SYSTEM 4-56
  - 422.1 Limestone Source and Characteristics 4-56
  - 422.2 Limestone Handling System 4-60
- 423 ELECTRICAL AND CONTROL SYSTEMS 4-60
  - 423.1 Auxiliary Power Unit (APU) 4-60
  - 423.2 SO_2 and O_2 Analyzers 4-62
  - 423.3 Steam Flow Transmitter 4-62
  - 423.4 Changes to Control Logic 4-62
  - 423.5 Dust Problem 4-63
- 424 BALANCE OF PLANT 4-63
  - 424.1 High Noise Level 4-63
  - 424.2 Oil in Deaerator 4-64
  - 424.3 Damage to Hotwell Lining 4-65
  - 424.4 Leakage into Condensate Line 4-65

4.3 DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILERS FBB-1 AND FBB-2 4-69

PART 5 - PHOTOGRAPHS

APPENDIX I TYPICAL ANALYSES OF COALS USED IN THE FBB PLANT AT CANADIAN FORCES BASE IN SUMMERSIDE' PRINCE EDWARD ISLAND

TABLE OF FIGURES

FIGURE NO.	TITLE	PAGE
2-1	Site Layout	2-4
2-2	Plant Layout	2-5
2-3	Flow Diagram - Coal and Wood	2-7
2-4	Flow Diagram - Limestone	2-8
2-5	Fluidized Bed Boiler - Cross-Sectional Elevation	2-14
3-1	Numbering of Water-Wall and In-Bed Tubes in FBB-1 and FBB-2 (NTS)	3-20
3-2	Cross-Sectional Elevation A-A Showing In-Bed Tubes (NTS)	3-21
3-3	Schematic of Refractory and Scalloped Bars Applied to Membrane Walls	3-22
3-4	Erosion Despite the Scalloped Bars (Sheds)	3-23
3-5	Orientation of the Carbon Steel Rods Applied to the In-Bed Tubes	3-24
3-6	Orientation of the Pin Studs on the Membrane Wall Tubes	3-25
4-1	Schematic of the New Fly Ash Reinjection System	4-66
4-2	Schematic of the Inter-Bed Transfer Gate, as Originally Installed and as Modified	4-67
4-3	Bed Thermocouple Installation as Originally Provided and as Modified	4-68

PART 1

EXECUTIVE SUMMARY AND CONCLUSIONS

1.1 EXECUTIVE SUMMARY

110 GENERAL

This report evaluates the performance and operation of the atmospheric fluidized bed boiler (FBB) demonstration plant, constructed in 1982 with a capacity which is adequate to serve the winter heating load of the Canadian Forces Base at Summerside, Prince Edward Island on the Atlantic coast of Canada.

The demonstration plant met all its contractual performance commitments in terms of capacity, efficiency and emission control, while firing low grade eastern Canadian coals. The knowledge that the plant could perform satisfactorily under stable operating conditions, if it could overcome its erosion and operating problems, was a major factor in the owner's decision to expend the resources necessary, over a four year period, to resolve those specific problems.

Part 2.2 contains a description of the plant as constructed and ready for commissioning in November 1982. Briefly, the FBB plant has two identical, but opposite handed, boilers, each rated to supply 18 Mg/h (40,000 pph) of saturated steam at MCR at 760 to 950 kPa (110 to 140 psig) from feedwater at 105°C (221°F). Each FBB has two beds. Bed 'A', the preferential bed is 1.22 m x 2.9 m and bed 'B', the secondary bed, is 1.37 m x 2.9 m. Figures 3-1 and 3-2 show the boiler arrangement and Figure 2-5 shows a cross-sectional elevation. Bed 'A', which is the preferential and also the start-up bed, is equipped with an ignition burner and is also equipped to be fed with either wood or with coal and limestone. Bed 'B' has no ignition burner and has feed systems only for coal and limestone.

The FBB plant is specifically designed to fire low grade (high ash, high sulphur) coals without exceeding the emission limits specified in Table 2-5 of Part 2.2. To enable the fluidized beds to operate to these emission limits while firing coal with up to 6% sulphur, a limestone sorbent feed is provided to each bed at the end opposite to the stokers and bed drain. Thus, the limestone is forced to traverse the length of the bed in order to arrive as residue at the bed drain. By allowing the sorbent a long residence time in the bed a maximum of sulphur capture is achieved.

While crediting the boilers with performing to specification whenever they achieved stable operation, this evaluation dwells at length on the erosion and operational problems which the FBB plant encountered, and on the various modifications which the plant underwent in the course of efforts to solve its problems. It is believed that the modifications carried out, in particular during the 1985 and 1986 summer shutdowns, have been effective and that the plant will achieve a sustained and sustainable level of stable operation during the 1986/87 heating season. It is also believed that this plant now has normal life expectancy.

This evaluation is divided into two main sections: One constitutes Part 3 of the report, and deals with 'Furnace Tube Erosion'. The second constitutes Part 4 of the report, and deals with 'Plant Operation'. The findings of each section are summarized separately in Parts 111 and 112 below.

111 FURNACE TUBE EROSION

Furnace tube erosion was discovered very early in FBB-1, in less than 500 bed hours of operation, because operational problems caused forced outages and required repairs to be carried out within the furnace.

When the beds were cleared to carry out these repairs, the waterwall tubes in both beds of FBB-1 and the in-bed tubes in FBB-1/B were examined and showed evidence of severe polishing. The polishing was confined to a horizontal band on all the waterwalls ranging 24 in. to 48 in. above the distributor plate. It was evident, fluidized bed height being 54 in., that this polishing was due to bed turbulence. A detailed examination of metal loss led to the tentative conclusion that a downward washing action of perimeter turbulence was the chief cause of wastage. The in-bed tubes appeared to have suffered most on their down-facing surfaces, particularly the inside surface of the lower of the two bends of the sloping tubes.

The following action was discussed and agreed upon:

a. Since FBB-2 had not yet been operated, original tube thickness was measured and recorded.

b. Perimeter nozzles were installed in the distributor plate of FBB-2 to counter the downward washing action of perimeter turbulence. The tubes were examined after a trial period of 17 days of continuous operation, and it was determined that this measure did not prevent metal wastage of the waterwall tubes, even though it did alter the pattern of turbulence and have some minor beneficial side effects.

c. Lavalox refractory was applied to that section of the waterwall which was affected by perimeter turbulence. See Figure 3-2 and Photographs 3 and 4.

d. Bars were welded longitudinally to the in-bed tubes to protect them from erosion.

On operating the boilers after the application of Lavalox refractory, it was discovered that the pattern of perimeter turbulence had been altered by the zoned application of the refractory layer. Prior to its application there had been no evidence of metal loss in the areas of the membrane walls up to 24 in. above the distributor plate. After Lavalox application the pattern of peripheral turbulence changed sufficiently so the areas between the distributor plates and the lower edge of the Lavalox refractory layer began to show evidence of tube polishing.

In order to protect these areas, sheds (also termed 'scallcped bars') were installed as shown in Photographs 6, 7 and 8 and in Figure 3-3. The installation of these sheds was carried out in August 1984. These sheds proved to be sacrificial appendages which bore the brunt of the turbulent attack and which, by their presence, again changed the pattern of perimeter turbulence. Also, it was discovered that they were not entirely effective in preventing tube metal loss, particularly in the area immediately below the highest shed.

A further effect of the application of Lavalox refractory over a fairly large proportion of the waterwall which interacted with the fluidized bed, was to change the original heat exchange area and, consequently, the temperature control in the fluidized bed and its excess air requirement. The boilers had now to be operated with about twice the excess air percentage for the same bed temperature and output. The higher air flow, which was used to control the bed temperature, increased the turbulence and particle velocity in the bed and, consequently, the potential for erosion of both metal and refractory. The sheds were the most obvious and immediate victims of this phenomenon.

It has been mentioned that the in-bed tubes in bed 'B' suffered severe erosion. These tubes had hard 'Alonized' surface treatment factoryapplied to them during boiler manufacture. Bed turbulence wore away and spalled this Alonized layer, as seen in Photographs 5, 18 and 19. Photograph 20 shows the extent and pattern of wear on the lower circumferential area of the in-bed tubes.

Since neither the Lavalox refractory nor the sheds were considered effective as long term solutions to the problem of tube metal loss, it was decided to stud the membrane wall tubes. DND and CANMET personnel discussed the problems of Summerside with the operating personnel of the fluidized bed boilers at Georgetown University and Idaho Falls and, in the summer of 1985, the following modifications were made to both the fluidized bed boilers at CFB Summerside:

- All the sheds (scalloped bars) were removed.
- The protective refractory was removed from bed 'A', but not from bed 'B', because of inadequate access.
- Pin studs were spot-welded to all exposed membrane wall tubes from the level of the distributor plate to a height of 1525 mm (60 in.). The studs, 9.5 mm (0.375 in.) in diameter and 19 mm (0.75 in.) long, were closely spaced, vertically oriented alternatively at 10, 12 and 2 o'clock or 11 and 1 o'clock, as shown in Figure 3-6.
- To protect the in-bed tubes, carbon steel rods, 9.5 mm (0.375 in.) in diameter were welded to them longitudinally at the 1, 4, 6, 8 and 11 o'clock positions, as shown in Figure 3-5. The rods were welded continuously on both sides to ensure good heat transfer. At a few locations, the tubes were so thinned by erosion that they burned through during welding, and localized repairs were required.

FBB-2 resumed service in September 1985. It was found that replacement of the refractory with the pin studs substantially improved heat transfer, as evidenced by an increase of almost 50% in boiler capacity, and a reduction in excess air to the 50-60% range. An inspection after 2500 hours of operation revealed that none of the tube surfaces showed any signs of polishing; instead they were covered with a thin, black carbonaceous deposit. Some of the studs had rounded tips whereas others were capped with a partially-sintered deposit of ash. Substantial quantities of gravel-sized shale particles were trapped between the studs in a band 380 to 890 mm (15 in. to 35 in.) above the distributor plate. The in-bed tubes likewise revealed no wastage beyond some polishing of the protective rods. Photographs 20, 21, 22 and 23 show the bars which were welded longitudinally to the in-bed tubes, and were successful in preventing further metal loss.

Another inspection in March 1986, after a further 2000 hours of operation, showed conditions to be substantially similar.

See Photographs 10 through 16, 24, 25, 26 27, 31 and 34.

Although further operating experience is needed for confirmation, it does appear that the problem of erosion has, in the main, yielded to the latest modifications and a reasonable furnace life may now be expected with normal inspection and maintenance.

Tube thickness measurements were taken frequently and, using some sets of readings, contour plots have been prepared. These give a reasonably correct visual indication of the pattern of wear experienced by the boiler waterwalls. The contour plots are included in Part 3 of the report along with the tables of readings used in their preparation.

112 PLANT OPERATION

The evaluation of plant operation has been carried out more or less on the basis of individually evaluating the performance and operation of a system or a group of systems. This summary will briefly review the findings of the report in the same arrangement and order.

112.1 Fluidized Bed Systems

ASH REINJECTION

The fly ash reinjection system is described in Part 2.2. Fly ash is collected at two locations, first under the boiler convection banks in the mud drum hopper and then, further downstream in the gas path, in the mechanical dust collector. Since elutriation from the fluidized bed deposits unburnts in both these locations, each must be equipped with a system to discharge the build-up in its hopper and reinject the discharge to the fluidized bed for complete burn-out. Whereas reinjection from the mud drum hopper was effected by the use of simple eductors, reinjection from the dust collector was achieved using a pneumatic double lock hopper system (seen in Photograph 32).

It was quickly found that both systems were subject to severe erosion and to mechanical failure. One system was pneumatically actuated and both systems employed pneumatic transport of the collected particles. The abrasive particles entrained in their respective air streams eroded the metal of their transport piping and the metal of the nozzles which finally injected them into the fluidized beds. Particle impingement was also the cause of many mechanical failures of the double lock hopper system.

On one occasion the failure of a simple component permitted coarse ash to be discharged through a vent line into the baghouse, causing extensive damage both to the baghouse and, further downstream, to the ID fan which had to be entirely replaced.

The positive displacement blowers which provided the air supply for the pneumatic transport systems were very noisy.

In the summer of 1985 the reinjection system from the dust collector of FBB-2 was replaced by a simpler Z-section piping system with air injection at specific points. A schematic of the new system is seen in Figure 4-1 and some views of it are shown in Photographs 28, 29, 30 and 31. This system works well, and a similar system replaced the double lock hoppers in November 1985 in FBB-1. The reduced air requirement of this system also resulted in reducing the level of plant noise by making one of the positive displacement blowers redundant.

In the summer of 1986 it is planned to replace the existing reinjection system from the mud drum hoppers with similar Z-section piping systems.

STOKERS

The stokers suffer severely from wet coal fines which cake, clog and plug up the rotor and build up in the pan below the rotor. All efforts to resolve the problem, including air injection at strategic points have so far failed, and this item of equipment remains the most frequent cause of boiler fluctuation and operator intervention.

FURNACE COMPONENTS

The furnace components consist of:

- Inter-bed transfer gate.

- Distributor plate and nozzles.

- Thermocouples and thermowells.

The interbed transfer gate as originally designed (see Figure 4-2 and Photograph 37) never operated well. It stuck open, stuck closed or stuck partly open. In the summer of 1985 it was redesigned (see Figure 4-2 and Photograph 38 and 39) and has operated well during the 1985/86 heating season. The permanent opening which has replaced the gate seals itself under normal conditions, and if a crust forms to prevent transfer of material when required, the two air jets are able to clear it and promote bed material movement. The permanent opening does not permit the two beds to operate at different levels, but that shortcoming does not represent a major operating problem.

DISTRIBUTOR PLATE, NOZZLES, THERMOCOUPLES AND WELLS

These components together form essentially one assembly and are functionally interdependent. The experience of the last four years with this FBB plant has taught the following lessons:

- There should be a sufficient number of nozzles to fluidize the bed without the use of reinjection air. During commissioning and initial operation FBB-1/A and FBB-2/A were found not to have adequate numbers of nozzles. Even a low level of bed material was difficult to fluidize on start-up.

- Start-ups generally resulted in high surface temperatures which destroyed thermocouples and thermowells.

- The T-shaped nozzles were originally bolted to the distributor plate (see Photograph 42). The thermowells also were similarly fastened. This fastening was found inadequate and all nozzles and thermowells have now been welded to the distributor plate.

- The air jets from the T-heads of the nozzles emerge horizontally and entrain ash and fuel particles. When these entrained particles impinge at high velocities on contiguous surfaces, they cause severe erosion. Membrane wall tubes, thermowells, and nozzles suffered from such erosion. Now all nozzles have been so oriented that air entrained particles do not impinge on contiguous surfaces. See Photographs 35, 42, 43 and 44, some of which show the orientation of the T-shaped heads of the nozzles.

BOILER AND FLUIDIZED BED

The boilers have performed to specification in terms of capacity, efficiency and emission control on both coal and wood firing.

Now that the nozzle, thermocouple, interbed transfer gate and erosion problems have been solved, the fluidized bed performs satisfactorily when design limestone and coal are fed to it. The bed is still subject to clinker formation, but this now depends more on fuel quality and on operating procedures than on factors related to bed design.

Since the removal of the Lavalox refractory, and the studding of the waterwalls the boiler capacity has increased and the furnace operates at high combustion efficiency at acceptable air to fuel ratios. The reduction in air flow results in less carryover, and consequently reduced loading on both the reinjection and fly ash collection systems. It should be noted that excess air is still maintained at a higher than desirable level in order to control the temperature in both beds.

112.2 Ash Systems

BOILER ASH

Boiler or bottom ash flows into the bed drain which directs it by gravity to twin-screw augers which are cooled by condensate recirculation. The screws discharge the ash into hoppers which, in turn, are cleared by a pneumatic ash handling system.

The bed drain system encountered the following problems, mainly because the bed drain coolers were selected for material having a density of 50 lb/cu.ft. (800 kg/m^3, whereas the actual density of the bed drain material is 80 to 90 lb/cu.ft. (1280 to 1440 kg/m^3):

- Clogging and plugging of the downcomer as well as the augers by large lumps, generally clinkers.

- Shear pin breakage when the augers were unable to move large lumps.

- Bending of the middle sections of the auger flights.

- Inadequate drive torque at low auger rpm.

These problems have been solved mainly by a combination of better fluidized bed control, which results in less clinker formation, and a change in the auger operating mode. From continuous variable speed operation, based on maintaining bed height, which provided insufficient torque at low auger rpm, the system was changed to a non-continuous single speed mode which started up the augers at a high bed height setting and stopped them at a low bed height setting. Due to control malfunction the augers are currently operated manually.

FLY ASH

The baghouse collects the fly ash, cleans the bags by reverse pulsed-jet air and drops the ash into fly ash hoppers which are cleared by the same pneumatic ash handling system which collects boiler ash.

The bags suffered significant damage from the stop-go operation of the boilers combined with the high moisture content in the pulsed air and in the fuel. This resulted in caking and clogging of the ash on the bag surfaces and within the interstices of bag fabric. A dryer was incorporated into the pulsed air cleaning system, but this, naturally, had no impact on the high moisture in the flue gas. These factors, combined with boiler operation at high excess air levels during the time that zones of the furnace waterwalls were covered with Lavalox refractory (see Photographs 4, 17, 19 and 26), resulted in a significant reduction in bag life.

It is expected that the modifications made in the summer shutdowns in 1985 and 1986 will allow continuous boiler operation at low draft conditions, and this will improve baghouse performance. Also, longer bags have been purchased in order to cope with the increased gas volume and higher fly ash loading.

112.3 Draft System

The draft system has had some problems of its own which are described later but, more important, it has suffered from other system problems. For example a mechanical component failure in an ash reinjection system allowed coarse ash to enter the baghouse, rupture the bags, get sucked into the ID fan and erode it to the extent that the entire fan had to be replaced.

112.4 Common Systems

FUEL HANDLING SYSTEM

This system is still the most problem-ridden system in the plant. If design coal, as supplied to the plant, is loaded directly into the coal transport system shown in Figure 2-3, then system problems are less frequent and not as severe. The design coal as specified is permitted up to 10% moisture and 20% passing 28 mesh. The specifications for the demonstration fuel are even more lax. The coal handling system clogs up even when handling coal at less than 10% moisture and less than 20% fines. The situation is aggravated by the coal receiving and stockpiling procedure which breaks up the coal, creating a very high percentage of fines, and permits it to acquire a high moisture content in the stockpiles. Consequently the coal which is fed into the system may be substantially degraded when compared with the coal which is delivered.

Since the beginning of the 1985-86 heating season coal has been delivered directly to the plant handling system, and gets stored in the plant bunkers, by-passing yard stockpiling. This procedure has reduced the problem to manageable proportions.

LIMESTONE HANDLING SYSTEM

Once the limestone fluidization problem was solved by reducing the pressure drop across the distributor plate, there have been no significant upsets in the material or in its handling system. It is important to correctly specify limestone, then to manage storage and handling so that it enters the fluidized bed as specified. However, dust generated during limestone handling continues to be a problem.

ELECTRICAL AND CONTROL SYSTEMS AND BALANCE OF PLANT

The electrical equipment has suffered from high dust loading in the plant air. More of the equipment should have been specified to dust-tight classifications.

The auxiliary power unit (APU) experienced start-up problems due to inadvertent errors in the sizing of overload protection components. When these were replaced, and modifications were made to the stepped voltage starters of the FD fans, the APU was capable of supplying sufficient power to operate one boiler at about 80% MCR.

The balance of plant had a few problems which have been discussed only cursorily in this report since they were not of a nature specific to FBB plants.

Plant environment, from the point of view of operator comfort, has been less than satisfactory. Equipment noise levels were, and still are, too high, and the plant heating system was ill-designed. Little consideration was given to operator comfort. Modifications have been carried out to improve the situation.

1.2 CONCLUSIONS

The following main conclusions are drawn from the findings of this report:

- The fluidized bed boiler demonstration plant was a distinct success from the point of view of plant capacity, operating efficiency and emission control, when the plant achieved stable operation.

- The boilers, however, encountered such serious erosion and operational problems that stable operation could not be achieved on the basis of the original design of some of its major systems. The problems encountered in operating under original design conditions seriously threatened boiler and overall plant life.

- In particular, the fluidized bed system components and the ash reinjection system components had to undergo major modifications in order to achieve stable, low-maintenance plant operation, and normal boiler and plant life expectancy.

- It is believed that the plant, as now modified, may expect consistently to achieve stable operation and normal life expectancy with normal preventive and planned maintenance. For this, thanks are due to the unrelenting and dedicated efforts of the Canadian Forces Base, particularly the C.O.E. at the time, Mr. E. Laughlin, and the Base staff of Defence Construction (1951) Limited, plant operating personnel, the staff of CANMET/EM&R, and to the cooperation extended to them by Foster Wheeler Limited, particularly in terms of information on the operation of other FWL fluidized bed boilers in U.S.A. and Europe.

1.1 RÉSUMÉ

110 GÉNÉRALITÉS

Ce rapport évalue le rendement et le fonctionnement de la chaufferie à lit fluidisé à la pression atmosphérique (FBB) de l'usine-pilote construite en 1982 et ayant une capacité adéquate pour assumer la charge en chauffage au cours de l'hiver de la base des Forces Canadiennes de Summerside, à l'Île-du-Prince-Édouard, sur la côte Atlantique du Canada.

L'usine-pilote a respecté tous ses engagements contractuels de rendement pour ce qui est de la capacité, de l'efficacité et du contrôle des émissions tout en étant alimentée à partir de charbon de qualité faible provenant de l'est du Canada. Le fait de savoir que l'usine était en mesure de fonctionner de façon satisfaisante en présence de conditions d'exploitation stables si l'on parvenait à vaincre les obstacles relatifs à l'érosion et à l'exploitation, constituait un facteur important en ce qui concerne la décision du propriétaire de mettre en oeuvre les ressources nécessaires, sur une période de quatre ans, pour résoudre ces problèmes spécifiques.

La partie 2.2 contient une description de l'usine telle qu'elle fut construite et prête à être mise en service en novembre 1982. En bref, l'usine FBB comprend deux chaudières identiques opposées ayant chacune une capacité nominale de 18 Mg/h (40 000 lb/h) de vapeur d'eau saturée à sa valeur nominale maximum continue, à une pression de 760 à 950 kPa (110 à 140 lb/po^2 eff.) d'eau d'alimentation à 105 °C (221 °F). Chaque FBB comprend deux lits. Le lit A, lit préférentiel, mesure 1,22 m x 2,9 m et le lit B, lit secondaire, mesure 1,37 m x 2,9 m. Les figures 3-1 et 3-2 illustrent l'agencement des chaudières et la figure 2-5 montre une vue en coupe. Le lit A, lit préférentiel, est aussi le lit de départ et est doté d'un brûleur d'allumage et peut être alimenté au bois ou au charbon et calcaire. Le lit B ne comporte pas de brûleur d'allumage et n'est doté de systèmes d'alimentation que pour le charbon et le calcaire.

L'usine FBB est spécialement conçue pour être alimentée à partir de charbon de faible qualité (toute teneur en cendre et en soufre) sans dépasser les limites d'émission spécifiées au tableau 2-5 de la partie 2.2. Afin de permettre aux lits fluidisés de fonctionner en deçà de ces limites d'émission, tout en brûlant du charbon contenant jusqu'à 6 % de soufre, un sorbant de calcaire est fourni à chaque lit à l'extrémité opposée aux chauffeurs et aux dispositifs de drainage des lits. Ainsi, le calcaire doit passer à travers la pleine longueur du lit afin d'arriver en tant que résidu au drainage du lit. En permettant au sorbant d'atteindre une longue durée de passage dans le lit, on capte un maximum de soufre.

Tout en reconnaissant que les chaudières opèrent conformément aux spécifications chaque fois qu'elles atteignent un fonctionnement stable, cette évaluation se penche sur les problèmes opérationnels et d'érosion auxquels ont dû faire face les usines FBB et sur les différentes modifications auxquelles fut soumise la centrale dans un effort pour résoudre ces problèmes. On croit que les modifications apportées, en particulier lors des arrêts durant les étés 1985 et 1986, ont été efficaces et que l'usine atteindra un niveau soutenu et soutenable d'exploitation stable au cours de la saison hivernale de 1986-1987. On croit également que cette usine a maintenant une durée utile normale prévue.

Cette évaluation se divise en deux sections principales : la première constitue la partie 3 du présent rapport et traite de "l'érosion des tubes de la fournaise". La deuxième constitue la partie 4 du présent rapport et traite de "l'exploitation de l'usine". Les conclusions de chacune de ces sections sont résumées séparément aux sections 111 et 112 ci-dessous.

111 ÉROSION DES TUBES DE LA FOURNAISE

On a noté très tôt l'érosion des tubes de la fournaise à FBB-1, après moins de 500 heures de fonctionnement des lits, puisque des problèmes opérationnels avaient entraîné des arrêts forcés exigeant que des réparations soient effectuées à l'intérieur de la fournaise. Lorsque les lits ont été vidés afin d'effectuer ces réparations, les tubes à écran d'eau des deux lits de FBB-1 et les tubes des lits de FBB-1/B ont été examinés et on a constaté un polissage marqué des surfaces. Le polissage était restreint à une bande horizontale sur tous les tubes à écran d'eau, de 24 à 48 po au-dessus de la plaque du distributeur. De toute évidence, la hauteur du lit fluidisé étant de 54 po, ce polissage était attribuable à la turbulence des lits comme tel. Un examen détaillé des pertes de métal a permis de conclure provisoirement que l'action de râclage vers le bas de la turbulence périmétrique était la cause principale de cette perte de métal. Les tubes à l'intérieur des lits se sont révélés plus endommagés sur leur surface faisant face vers le bas, tout particulièrement la surface intérieure du plus bas des deux coudes des tubes inclinés.

Les mesures suivantes firent l'objet d'ententes :

a. Étant donné que FBB-2 n'avait encore jamais fonctionné, l'épaisseur originale des tubes fut mesurée et enregistrée.

b. Les tuyères périmétriques furent installées sur la plaque du distributeur de FBB-2 de façon à contrer l'action de râclage vers le bas attribuable à la turbulence périmétrique. Après une période d'essai de 17 jours de fonctionnement continu, les n'empêchait pas les pertes de métal des tubes à écran d'eau, bien qu'elle modifiait la forme de la turbulence et présentait quelques effets secondaires mineurs et bénéfiques.

c. Le matériau réfractaire Lavalox fut appliqué à cette section des tubes à écran d'eau qui étaient affectés par la turbulence périmétrique. Voir la figure 3-2 et les photos 3 et 4.

d. Des barres furent soudées longitudinalement aux tubes des lits afin de les protéger contre l'érosion.

Lors de l'exploitation des chaudières, par suite de l'application du matériau réfractaire Lavalox, on nota que la forme de la turbulence périmétrique avait été modifiée par l'application zonée de couches de matériau réfractaire. Avant l'application, il n'y avait aucune indication de perte de métal dans les secteurs des parois à membranes jusqu'à 24 po au-dessus de la plaque du distributeur. Après l'application du Lavalox, la forme de la turbulence périphérique fut suffisamment modifiée pour que les surfaces entre les plaques du distributeur et le rebord inférieur de la couche du matériau réfractaire Lavalox commencent à démontrer une évidence de polissage de tubes.

Afin de protéger ces secteurs, des barres découpées ont été installées en août 84 tel qu'indiqué sur les photos 6, 7 et 8 et à la figure 3-3. Ces barres se sont avérées être des prolongements sacrifiés qui absorbaient le choc de l'attaque turbulente et qui, par leur présence, changeaient à nouveau la forme de la turbulence périmétrique. On découvrit également qu'elles n'étaient pas entièrement efficaces dans la prévention de la perte de métal des tubes, tout particulièrement dans le secteur immédiatement sous la plus haute barre.

L'application du matériau réfractaire Lavalox sur une partie relativement grande des tubes à écran d'eau en interaction avec le lit fluidisé eut aussi comme effet de changer l'aire d'échange de chaleur originale et conséquemment, le contrôle de la température dans le lit fluidisé et le besoin en air excédentaire. Les chaudières devaient maintenant être exploitées avec environ deux fois le pourcentage d'air excédentaire pour la même température de lit et le même rendement. Le plus grand volume d'air qui était utilisé pour contrôler la température du lit augmenta la turbulence et la vélocité des particules dans le lit et, par conséquent, le potentiei d'érosion du métal et du matériau réfractaire. Les barres furent les premières et les plus évidentes victimes de ce phénomène.

On a mentionné que les tubes dans les lits du lit B furent soumis à une érosion considérable. Ces tubes présentaient un traitement en surface "alonisé" appliqué à l'usine lors de la fabrication des chaudières. La turbulence du lit a usé et effrité cette couche alonisée tel qu'illustré sur les photos 5, 18 et 19. Sur la photo 20, on voit l'étendue et la forme que prend l'usure sur la superficie circonférencielle inférieure des tubes dans les lits.

Puisque ni le matériau réfractaire Lavalox ni les barres sont considérés efficaces comme solution à long terme au problème de perte de métal des tubes, on a décidé de renforcer les tubes de parois à membrane. Le personnel du ministère de la Défense nationale et de CANMET a étudié les problèmes de Summerside avec le personnel d'exploitation des chaudières à lits fluidisés à l'université de Georgetown et Idaho Falls et, à l'été 1985, les modifications suivantes étaient apportées aux deux chaudières des lits fluidisés à la base des Forces canadiennes de Summerside :

- Toutes les barres ont été enlevées.

- Le matériau réfractaire protecteur a été enlevé du lit A mais non du lit B étant donné l'accès inadéquat.

- Les goujons ont été soudés par points à tous les tubes de parois à membrane à partir du niveau de la plaque de distributeur jusqu'à une hauteur de 1 525 mm (60 po). Les goujons de 9,5 m (0,375 po) de diamètre et de 19 mm (0,75 po) de longueur, ont été étroitement espacés dans le sens de la verticale en alternance à 10, 12 et 2 heures ou 11 et 1 heure, tel qu'indiqué à la figure 3-6.

- Pour protéger les tubes dans les lits, des tiges d'acier au carbone de 9,5 mm (0,375 po) de diamètre leur ont été soudés longitudinalement aux positions de 1, 4, 6, 8 et 11 heures, tel qu'indiqué à la figure 3-5. Les tiges ont été soudées en continu de part et d'autre afin d'assurer un bon transfert de la chaleur. À quelques endroits, les tubes avaient été tellement amincis par l'érosion qu'ils furent brûlés de part en part au cours du soudage et des réparations localisées furent nécessaires.

FBB-2 fut remis en service en septembre 1985. On nota que le remplacement du matériau réfractaire par des goujons améliorait considérablement le transfert de la chaleur, et ceci s'est manifesté par une augmentation de presque 50 % à la capacité des chaudières et une réduction de l'air excédentaire à une plage de 50 à 60 %. Une inspection effectuée après 2 500 heures de fonctionnement a révélé qu'aucune des surfaces de tubes ne présentait un polissage; ils étaient plutôt recouverts d'un mince dépôt noir charbonneux. Certains des goujons présentaient des bouts arrondis alors que d'autres étaient recouverts d'un dépôt de cendre partiellement trittée. Des quantités assez importantes de particules de schiste ayant la grosseur de gravillons étaient emprisonnées entre les goujons sur une bande de 380 à 890 mm (15 à 35 po) au-dessus de la plaque du distributeur. Les tubes dans les lits indiquaient de même aucune perte au-delà d'un certain polissage des tiges protectrices. Les photos 20, 21, 22 et 23 montrent les barres qui étaient soudées longitudinalement aux tubes dans les lits et qui empêchèrent avec succès une perte de métal plus grande.

Une autre inspection en mars 1986, après 2 000 heures supplémentaires de fonctionnement, indiqua des conditions passablement semblables.

Voir les photos 10 à 16 et 24, 25, 26, 27, 31 et 34.

Bien qu'une expérience d'exploitation plus grande soit nécessaire pour confirmation, il semble que le problème de l'érosion ait, dans l'ensemble, été résolu par les plus récentes modifications et qu'une durée utile raisonnable des fournaises puisse maintenant être prévue en effectuant des inspections et des entretiens normaux.

Les mesures d'épaisseur de tubes furent prises fréquemment et, à l'aide de lectures groupées, des tracés ont été préparés. Ces mesures donnent une indication visuelle raisonnablement précise du motif de l'usure à laquelle furent soumises les parois des chaudières. Les tracés sont inclus à la partie 3 du rapport avec les tableaux de lecture utilisés dans leur préparation.

112 EXPLOITATION DE L'USINE

L'évaluation de l'exploitation de l'usine a été effectuée plus ou moins sur une base d'évaluation individuelle du rendement et d'exploitation d'un système ou d'un groupe de systèmes. Ce sommaire passera brièvement en revue les conclusions du rapport suivant le même ordre.

112.1 Systèmes de lits fluidisés

RÉINJECTION DES CENDRES

Le système de réinjection des cendres volantes est décrit à la partie 2.2. La cendre volante est recueillie à deux endroits; premièrement, sous les groupes à convexion de la chaudière dans la trémie à tambour de boues puis ensuite en aval dans le jet de gaz situé dans le collecteur de poussières mécanique. Puisque la décantation des dépôts des lits ne brûle pas (de gaz) dans ces deux endroits, chacun d'eux doit être doté d'un système pour refouler l'accumulation de particules dans sa trémie et réinjecter le produit déchargé du lit fluidisé pour en assurer la combustion complète. Alors que l'on a assuré la ré-injection de la trémie à tambour de boues en faisant appel à de simples éducteurs, la ré-injection depuis le collecteur de poussière a été obtenue en utilisant un système à trémie à double verrouillage pneumatique. (Voir Photo 32).

Il s'est rapidement révélé que les deux systèmes étaient sujets à une sévère érosion et à des pannes mécaniques. Un système était à commande pneumatique et les deux systèmes faisaient appel au transport pneumatique des particules recueillies. Les particules entraînées dans leur jet d'air respectif ont érodé le métal de leur tuyauterie de transport et le métal des tuyères qui les injectaient dans les lits fluidisés. La présence de particules était aussi la cause des pannes mécaniques du système de trémies à double verrouillage.

Dans un cas particulier, la défaillance d'un simple composant permit le refoulement de cendres grossières dans une canalisation d'évent dans le bâtiment d'ensachage causant d'importants dommages à celui-ci et, plus en aval, au ventilateur ID qui dût être remplacé.

La soufflerie volumétrique fournissant l'alimentation en air pour les systèmes de transport pneumatique était très bruyante.

Au cours de l'été 1985, le système de réinjection du collecteur de poussière de FBB-2 fut remplacé par un système à tuyauterie à coupe en Z plus simple avec injection d'air à des points spécifiques. Un schéma du nouveau système est présenté à la figure 4-1 et les photos 28, 29 30 et 31 nous en donnent un aperçu. Ce système fonctionne bien et, en novembre 1985, un système semblable a remplacé sur FBB-1, les trémies à double verrouillage. La quantité d'air moindre requise par ce système a permis de réduire le niveau de bruit dans l'usine puisqu'un des ventilateurs de la soufflerie devenait inutile.

Au cours de l'été 1986, on prévoit remplacer le système de réinjection actuel des trémies à tambour de boues par des réseaux de tuyauteries semblables à coupe en Z.

CHAUFFEURS

Les chauffeurs souffrent beaucoup des particules fines de charbon humides qui s'agglutinent, encrassent, et s'accumulent dans le bac sous le rotor. Tous les efforts faits pour résoudre ces problèmes, y compris l'injection d'air à des endroits stratégiques, ont jusqu'à maintenant échoué et c'est cette pièce d'équipement qui demeure la cause la plus fréquente de fluctuations des chaudières et d'interventions de la part des opérateurs.

COMPOSANTS DE LA FOURNAISE

Les composants de la fournaise comprennent :

- Porte de transfert entre lits
- Plaque de distributeur et tuyères
- Thermocouples et puits thermométriques

La porte de transfert entre lits telle qu'elle fut conçue à l'origine (voir figure 4-2 et photo 37) n'a jamais bien fonctionné. Elle se bloquait en position ouverte ou fermée ou encore partiellement ouverte. Au cours de l'été 1985, elle fut redessinée (voir figure 4-2 et photos 38 et 39) et a bien fonctionné au cours de la saison froide de 1985/86. L'ouverture permanente qui a remplacé la porte est autoscellante en présence de conditions normales et si une croûte se forme pour empêcher le transfert des matériaux, s'il y a lieu, les deux jets d'air sont capables de déblayer l'ouverture et de faciliter le mouvement des matériaux entre les lits. L'ouverture permanente ne permet pas aux deux lits de fonctionner à des niveaux différents mais cette lacune ne représente pas un problème opérationnel majeur.

PLAQUE DE DISTRIBUTEUR, TUYÈRES, THERMOCOUPLES ET PUITS

Ensemble, ces composants forment un assemblage et sont fonctionnellement interdépendants. L'expérience des quatre dernières années avec cette centrale FBB a permis d'établir :

- Qu'il devrait y avoir un nombre suffisant de tuyères pour fluidiser le lit sans avoir à faire appel à une réinjection d'air. Au cours de la mise en service et de l'exploitation initiale, on a découvert que FBB-1/A et FBB-2/A comportaient un nombre insuffisant de tuyères. Même un faible niveau de matériau de lit ne pouvait être fluidisé rapidement lors de la mise en marche.

- Des températures de surface élevées étaient généralement présentes lors de la mise en marche et détruisaient les thermocouples et les puits thermométriques.

- Les tuyères en forme de T étaient à l'origine boulonnées à la plaque du distributeur (voir photo 42). Les puits thermométriques étaient fixés de la même façon. Cette fixation s'est avérée inadéquate et toutes les tuyères et les puits thermométriques sont maintenant soudés à la plaque de distributeur.

- Les jets d'air des têtes en T des tuyères sortent à l'horizontal et entraînent les particules de carburant et les cendres. Lorsque ces particules entraînées frappent à haute vélocité les surfaces contiguës, il se produit une importante érosion. Les tubes à paroi à membrane, les puits thermométriques et les tuyères ont été endommagés par une telle érosion. Les tuyères sont maintenant orientées de telle sorte que les particules entraînées d'air ne frappent pas les surfaces contiguës. Voir les photos 35, 42, 43 et 44 dont certaines montrent l'orientation des têtes en T des tuyères.

CHAUDIÈRE ET LIT FLUIDISÉ

Les chaudières se sont comportées conformément aux spécifications en terme de capacité, d'efficacité et de contrôle des émissions à l'utilisation de charbon et de bois comme carburant.

Maintenant que les problèmes relatifs aux tuyères, aux thermocouples, à la porte de transfert entre les lits et à l'érosion ont été résolus, les lits fluidisés se comportent de façon satisfaisante lorsque du calcaire et du charbon suivant une conception définie y sont alimentés. Le lit est encore sujet à la formation de scories mais ceci dépend maintenant davantage de la qualité du carburant et des méthodes opérationnelles que de facteurs liés à la conception des lits.

Depuis l'enlèvement du matériau réfractaire Lavalox, et de la pose de goujons sur les parois, la capacité de la chaudière a augmenté et la fournaise fonctionne à un rendement de combustion élevé suivant un rapport acceptable d'air par rapport au carburant. La réduction du débit d'air se traduit par un transfert de particules moins important et par conséquent, par une charge réduite sur les systèmes de réinjection et de collection de la cendre volante. Il faudrait noter que l'air excédentaire se maintient encore à une température supérieure au niveau souhaitable afin de contrôler la température dans les deux lits.

112.2 Systèmes de cendre

CENDRE DE CHAUDIÈRES

La cendre de fond ou de chaudière s'écoule dans le drain de lit qui l'achemine par des tarières à double vis sans fin alimentées par gravité qui sont refroidies par la recirculation du condensat. Les vis déchargent la cendre dans les trémies qui, à leur tour, sont déblayées par le système de manutention pneumatique de la cendre. Le système de drainage des lits a dû faire face au problème suivant, principalement parce que les refroidisseurs de drains des lits avaient été choisis en fonction d'un matériau ayant un poids spécifique de 50 lb/pi^3 (800 kg/m^3) alors que le poids spécifique véritable du matériau de drainage du lit était de 80 à 90 lb/pi^3 (1 280 à 1 440 kg/m^3):

- Encrassement et bouchonnage des tubes de déversoirs ainsi que des tarières par de gros morceaux, généralement des scories.

- Bris de la goupille de cisaillement lorsque les tarières étaient incapables de déplacer les gros morceaux.

- Déformation de la section médiane de la tige des tarières.

- Couple d'entraînement inadéquat en présence d'un faible nombre de tours/minute des tarières.

Ces problèmes ont été résolus principalement par la combinaison d'un meilleur contrôle des lits fluidisés qui se traduisent par une formation moindre de scories et par une modification du mode d'exploitation des tarières. Le système a été modifié d'un fonctionnement à vitesse variable soutenue basée sur une hauteur de lit constante qui assurait un couple insuffisant en présence d'une faible vélocité de la tarière, à un mode d'exploitation à vitesse non variable, non constante, qui met les tarières en marche à une hauteur de lit élevée et les arrête à un réglage de faible hauteur de lit.

CENDRE VOLANTE

Le bâtiment d'ensachage recueille la cendre volante, nettoie les sacs par jets d'air à impulsion inversée et laisse tomber la cendre dans des trémies de cendres volantes qui sont nettoyées à l'aide du même système de manutention pneumatique des cendres qui recueille la cendre des chaudières.

Les sacs ont été considérablement endommagés par le mode marche/arrêt d'exploitation des chaudières combiné à une forte teneur en humidité dans l'air pulsé et dans le carburant. Ceci s'est traduit par un agglutinage de la cendre et l'encrassement des surfaces des sacs et des interstices du tissu du sac. Un sécheur a été incorporé au système d'épuration de l'air pulsé, mais ceci n'a bien sûr pas eu d'impact sur la forte teneur en humidité des gaz de carneau. Ces facteurs, combinés à l'exploitation de la chaudière en présence de niveaux d'air excédentaire élevés, alors que les zones des parois de la fournaise étaient recouvertes du matériau réfractaire Lavalox (voir photos 4, 17, 19 et 26), se traduisirent par une réduction considérable de la durée utile du sac.

On s'attend à ce que les modifications apportées au cours des arrêts durant les étés 1985 et 1986 permettront le fonctionnement continu de la chaudière avec des conditions de faible appel d'air et que ceci améliorera le rendement du bâtiment d'ensachage puisqu'il n'y a rien qui soit incorrect en soi dans le système de cendre volante proprement dit.

112.3 Système d'appel d'air

Le système d'appel d'air a eu ses problèmes propres qui seront décrits ci-après, mais plus important encore, il a souffert de problèmes provenant d'autres systèmes. Ainsi, la panne d'un composant mécanique dans un système de réinjection de cendre a permis à des cendres grossières de s'introduire dans le bâtiment d'ensachage, de rompre les sacs et d'être aspirées dans le ventilateur ID et de l'éroder à tel point que l'ensemble du ventilateur dut être remplacé.

112.4 Système commun

SYSTÈME DE MANUTENTION DU CARBURANT

Ce système est encore celui qui présente le plus de problèmes à l'usine. Si le charbon conceptuel, tel que fourni à l'usine, est chargé directement dans le système de transport du charbon de la figure 2-3, les problèmes du système sont alors moins fréquents et pas aussi importants. Le charbon tel que spécifié peut avoir jusqu'à 10 % d'humidité et 20 % doit passer le tamis de maille 28. Les spécifications pour le carburant expérimental sont encore moins rigoureuses. Le système de manutention du charbon s'encrasse même lorsqu'il traite un charbon ayant moins de 10 % d'humidité et moins de 20 % de particules fines. Cette situation est accentuée par la méthode de réception et d'empilage du charbon qui fracture le charbon, créant un très haut pourcentage de particules fines et lui permettant d'acquérir une teneur en humidité élevée lors du stockage. Conséquemment, le charbon qui est alimenté au système peut être dégradé considérablement si on le compare au charbon qui est livré.

Depuis le début de la saison froide 1985-1986, le charbon a été livré directement au système de manutention de l'usine et est stocké dans des soutes, sans passer par la cour d'empilage. Cette façon de procéder a permis de réduire le problème à un niveau tolérable.

SYSTÈME DE MANUTENTION DU CALCAIRE

Une fois le problème de fluidisation du calcaire résolu en réduisant la chute de pression de part et d'autre de la plaque du distributeur, il y a eu des perturbations importantes au matériau ou à son système de manutention. Il est important de spécifier correctement le calcaire puis de gérer son stockage et sa manutention de sorte qu'il pénètre dans les lits fluidisés, tel que spécifié. Cependant, la poussière produite au cours de la manutention du calcaire continue de créer des problèmes.

SYSTÈMES ÉLECTRIQUES ET DE COMMANDE ET AUTRES PARTIES DE L'USINE

L'équipement électrique a été affecté par une forte charge de poussière dans l'air de l'usine. Une plus grande partie de l'équipement aurait dû être spécifiée suivant une catégorie dite étanche à la poussière.

L'unité d'alimentation auxiliaire a fait face à des problèmes de mise en marche dû à des erreurs de dimensionnement des composants de protection de surcharge. Lorsque ces composants ont été remplacés et que des modifications ont été apportées au démarreur de tension par incréments des ventilateurs FD, l'unité d'alimentation auxiliaire a été capable de fournir suffisamment d'énergie pour faire fonctionner une chaudière à environ 80 % d'allure continue de combustion maximale.

Le reste de l'usine a connu quelques problèmes qui font l'objet d'une revue sommaire dans ce rapport puisqu'ils n'étaient pas de nature spécifique aux usines FBB.

Le milieu de travail de l'usine, du point de vue confort de l'opérateur, a été moins que satisfaisant. Les niveaux de bruit des équipements étaient, et sont encore, trop élevés et le système de chauffage de l'usine a été mal conçu. On ne s'est guère soucié du confort des travailleurs. Des modifications ont été apportées afin d'améliorer cette situation.

1.2 CONCLUSIONS

Les principales conclusions qui suivent sont tirées des résultats de ce rapport :

- L'usine-pilote de chaudière à lits fluidisés s'est révélée un succès sans contredit du point de vue de la capacité, de l'efficacité et du contrôle des émissions de l'usine lorsque la centrale a atteint une exploitation stable.

- Cependant, les chaudières ont fait face à de si sérieux problèmes d'érosion et d'exploitation que le fonctionnement stable n'a pu être atteint sur la base de la conception originale de certains de ses principaux systèmes. Les problèmes rencontrés en présence des conditions conceptuelles originales ont sérieusement menacé la durée utile de la chaudière et de l'usine dans son ensemble.

- Les composants du système des lits fluidisés et du système de réinjection de la cendre durent particulièrement faire l'objet de modifications majeures afin d'atteindre un fonctionnement stable, de faible entretien, et une durée utile normale de la chaudière et de l'usine.

- On croit que l'usine telle que modifiée actuellement, pourrait atteindre un fonctionnement stable, constant, et une durée utile prévue normale grâce à un entretien préventif et planifié normal. À cette fin, nous remercions la base des Forces canadiennes, en particulier le président d'alors, M. E. Laughlin, et le personnel à la base de Defence Construction (1951) Limited, le personnel d'exploitation de l'usine, ainsi que le personnel de CANMET/EM&R, pour leurs efforts soutenus et leur dévouement. Nous remercions également Foster Wheeler Limited qui les a appuyés, tout particulièrement pour l'information fournie concernant l'exploitation d'autres chaudières FWL à lits fluidisés aux États-Unis et en Europe.

1.3 ABBREVIATIONS

The following abbreviations have been used in the text of this report.

AFBC	Atmospheric Fluidized Bed Combustor
DND	Department of National Defence
EPA	U.S. Environmental Protection Agency
FBB	Fluidized Bed Boiler
FBB-1	Fluidized Bed Boiler No. 1
FBB-2	Fluidized Bed Boiler No. 2
FBB-1/A	Fluidized Bed Boiler No. 1, Bed A
FBB-1/B	Fluidized Bed Boiler No. 1, Bed B
FWL	Foster Wheeler Limited
DCL	Defence Construction (1951) Limited
CFB	Canadian Forces Base
EM&R	Energy, Mines and Resources Canada
UCC	United Conveyor Corporation, Chicago, Illinois

PART 2

INTRODUCTION

2.1 BACKGROUND AND OBJECTIVES

The atmospheric fluidized bed boiler plant at the Canadian Forces Base, Summerside, P.E.I., was designed and constructed as a demonstration project jointly funded by Defence Canada and Energy, Mines and Resources Canada. Foster Wheeler Limited, Ontario, was the prime contractor with responsibility for supplying a turn-key steam plant consisting of two 18 Mg/h (40,000 pph) AFB boilers.

Construction, including boil-out, was completed by end November 1982. Commissioning started in December 1982 on unit number one (FBB-1) and the plant promptly ran into severe erosion and operating problems. Foster Wheeler took vigorous action to deal with these problems, obtaining all available assistance from FBB plant experience of their own boilers in U.S.A. and Europe. A variety of measures, expected to mitigate or resolve the problem, were put into effect, without significant success, over a period of about two years.

Boiler performance tests, however, clearly indicated that, in the main, boiler design was sound. During periods of stable operation the boilers performed to rated capacity, efficiency and emission control and fulfilled all contractual obligations in these respects when firing both coal and wood.

The success of the performance tests encouraged Defence Canada and EM&R Canada to continue their efforts to overcome the erosion and operational problems which plagued the units. Foster Wheeler, while contractually inactive, continued to provide assistance in the form of information and technical data from the operation of their other fluidized bed plant in Europe and U.S.A. Information from the operating personnel of the FBB plants at Georgetown and Idaho Falls was particularly helpful. It is greatly to the credit of all concerned that the modifications made by Defence Canada and EM&R Canada during the summer shutdowns in 1985 and 1986 have brought about a transformation.

The FBB plant at Summerside now expects to operate with reasonably good availability, reasonable levels of maintenance and a normal life expectancy.

The objective of this report, which dwells on those erosion and operational problems which are specific to FBB plants as distinct from conventional steam plants, is to record and evaluate the problems encountered and the success or otherwise of the measures adopted to mitigate or resolve those problems.

It is hoped that this report will be useful in the design and construction of other fluidized bed boiler plants, and that the lessons learned from the experience of this demonstration plant will be successfully applied to future design, construction and operation of FBB plants.

There can be little doubt today that FBC technology is mature and commercially viable for the combustion of low grade coals and wood under conditions of controlled emission.

2.2 DESCRIPTION OF "AS CONSTRUCTED" PLANT (NOV. 1982)

221 INTRODUCTION

Whereas the fluidized bed boiler (FBB) demonstration plant has undergone significant modifications as a result of operating experience over four heating seasons, the plant layout and arrangement remains basically unchanged. In order that the reader of this report may more readily appreciate the changes made, a description of the "as constructed" plant at the time of boil-out in November 1982 is given below.

222 PLANT LAYOUT

The site layout is illustrated in Figures 2-1 and 2-2.

The layout of the boilerhouse is such that the major load-bearing foundations, particularly those supporting the coal bunkers, are kept well clear of the foundations of the original Central Heating Plant No. 2. The intervening space is conveniently arranged to provide the following:

- Control room for both old and new units at a height mid-way between their respective firing positions.
- Superintendent's office at control room level.
- Washroom at control room level.
- Motor control centre below grade beneath the control room.
- Workshop at approximately grade level.
- Easy access between the two plants.

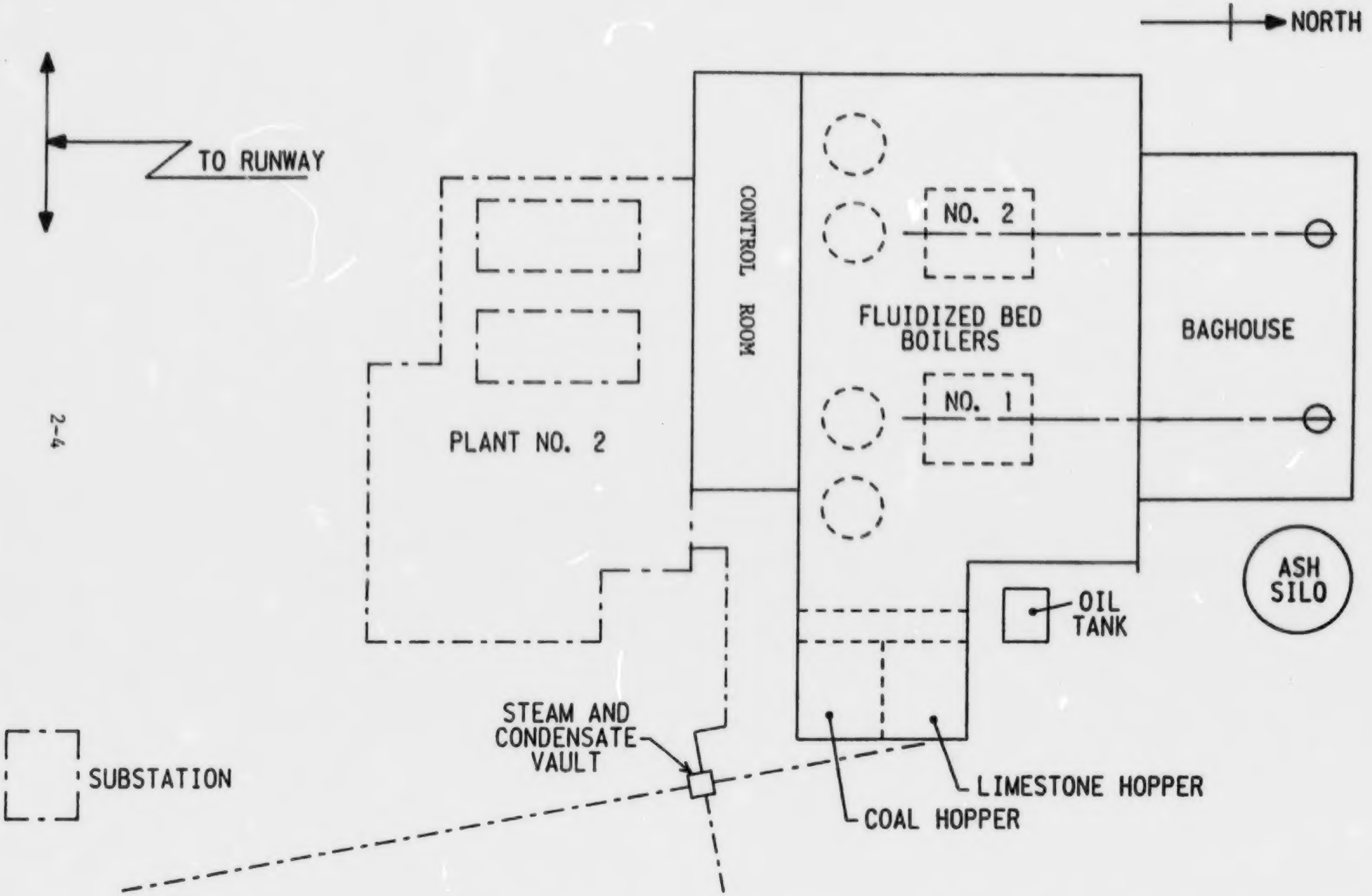
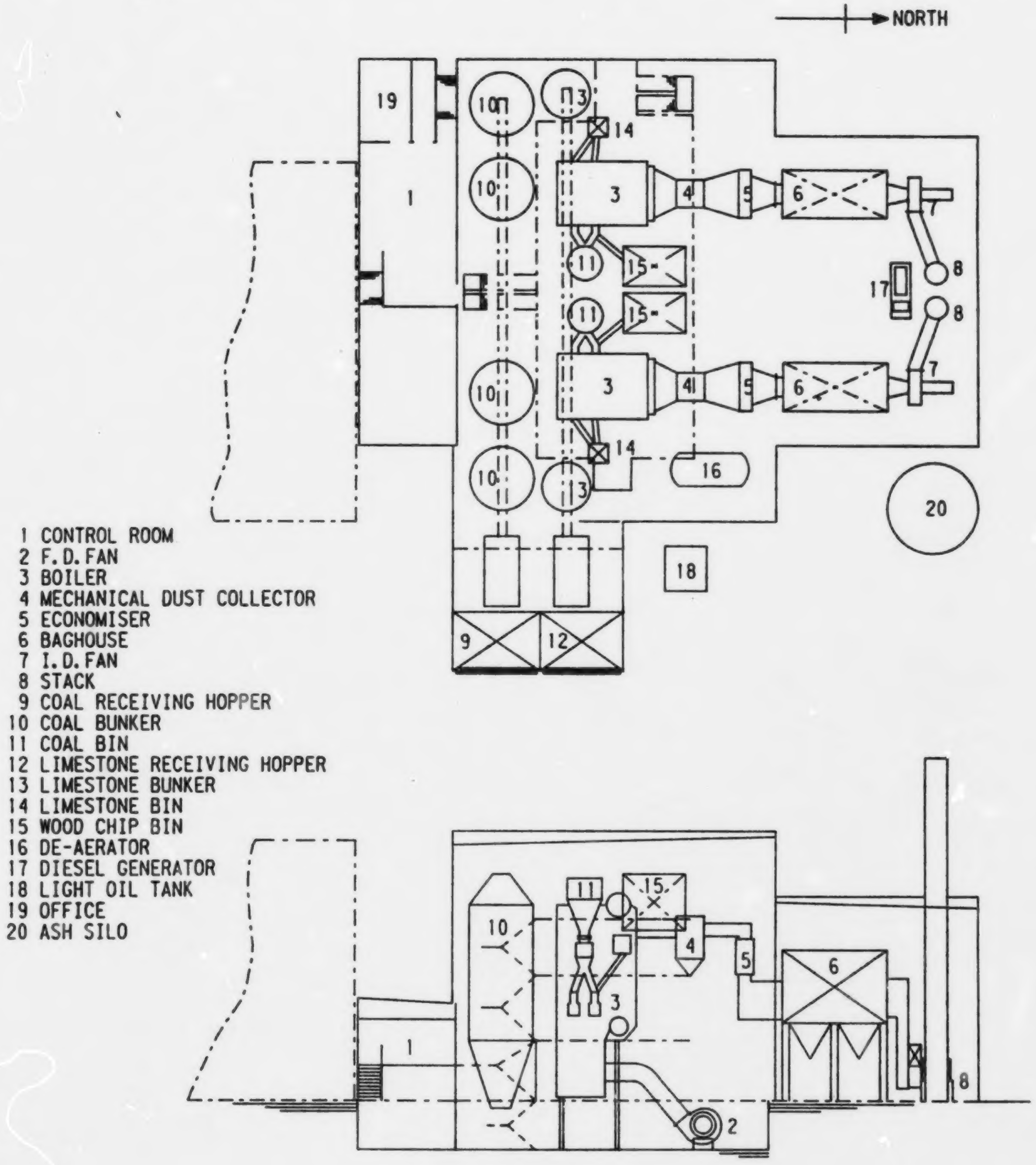

NORTH
TO RUNWAY
CONTROL ROOM
FLUIDIZED BED BOILERS
NO. 2
NO. 1
BAGHOUSE
PLANT NO. 2
ASH SILO
OIL TANK
STEAM AND CONDENSATE VAULT
SUBSTATION
LIMESTONE HOPPER
COAL HOPPER

Figure 2-1: Site Layout


NORTH
19
10
13
14
1
3
4
5
6
7
8
11
15
17
16
18
20
9
12
2

1 CONTROL ROOM
2 F.D. FAN
3 BOILER
4 MECHANICAL DUST COLLECTOR
5 ECONOMISER
6 BAGHOUSE
7 I.D. FAN
8 STACK
9 COAL RECEIVING HOPPER
10 COAL BUNKER
11 COAL BIN
12 LIMESTONE RECEIVING HOPPER
13 LIMESTONE BUNKER
14 LIMESTONE BIN
15 WOOD CHIP BIN
16 DE-AERATOR
17 DIESEL GENERATOR
18 LIGHT OIL TANK
19 OFFICE
20 ASH SILO

Figure 2-2: Plant Layout

223 MATERIALS STORAGE AND HANDLING SYSTEMS

Figure 2-3 shows a simplified flow diagram of the storage and handling facilities for coal and wood. Figure 2-4 shows a simplified flow diagram of the limestone storage and handling system.

223.1 Coal

With the exception of the wood, which is a local fuel, all fuels have to be shipped to Prince Edward Island. Coal is normally brought in by rail and ferry or by barge to the quay at Summerside and then trucked to an outdoor stockpile at the Canadian Forces Base (CFB), the stockpile being about half a kilometre from Plant No. 2. Stockpiling is usually carried out in summer or fall when transportation and weather are appropriate.

Inevitably, coal which is not under cover collects water while awaiting use, and in winter it is prone to freezing. When the coal is extracted under freezing conditions, efforts are made to remove loose coal from under the frozen crust of the stockpile to facilitate handling at the plant. To a limited extent, the plant bunkering system was designed to cope with wet or frozen coal.

Delivery from the stockpile to the plant is made by dump truck which discharges its load through a "grizzly" with 75 mm square openings into a hopper from which the coal is fed, by means of an elevator, to a vibrating screen. A tramp iron magnet is located between the hopper and bucket elevator. Oversized coal is separated by the screen and passed to a crusher for sizing. The screenings and the crushed coal rejoin and are elevated to a traverse conveyor passing over the tops of four coal bunkers, each having a capacity of 75 metric tonnes. These are arranged so that for normal operation two of them will serve one AFBC boiler while the other two will serve the second AFBC

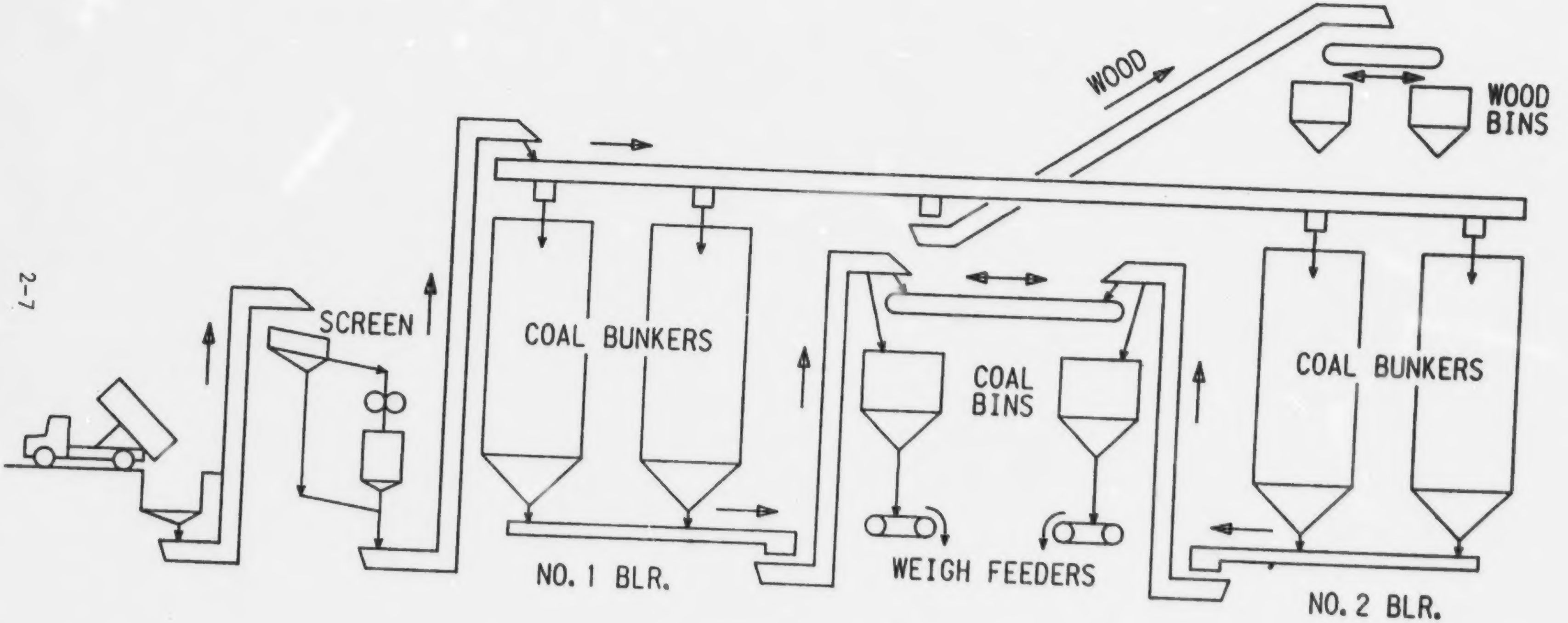
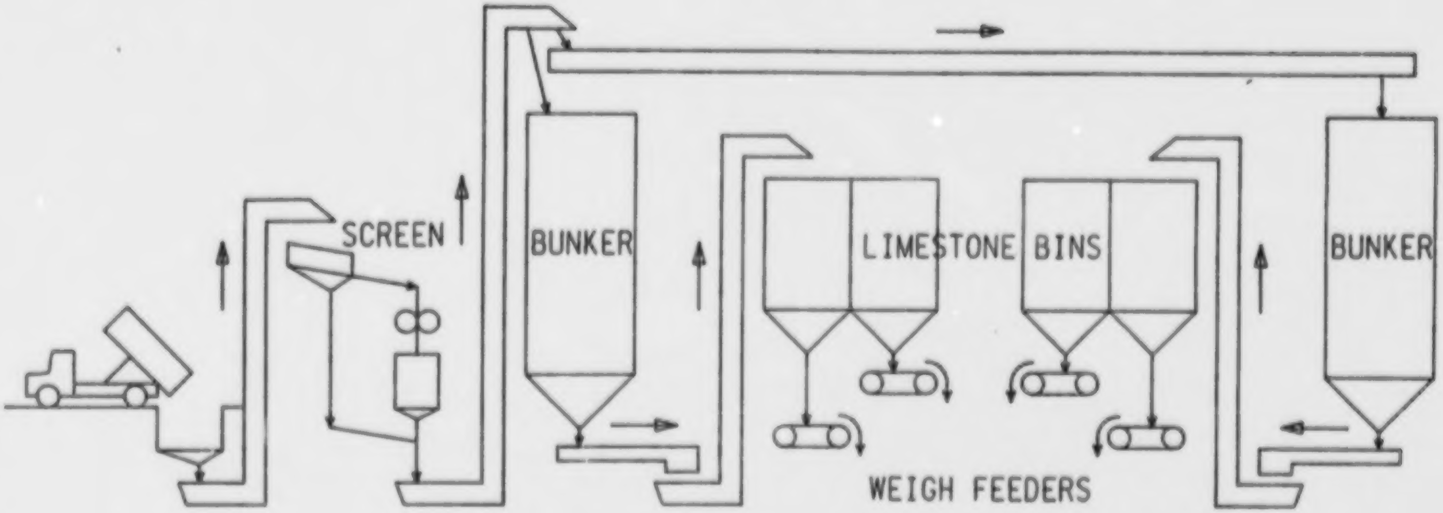

WOOD
WOOD BINS
SCREEN
COAL BUNKERS
COAL BINS
COAL BUNKERS
NO. 1 BLR.
WEIGH FEEDERS
NO. 2 BLR.

Figure 2-3: Flow Diagram - Coal and Wood


SCREEN
BUNKER
LIMESTONE BINS
BUNKER
WEIGH FEEDERS

Flow Diagram - Limestone

MATERIALS HANDLING - RATES AND CAPACITIES

	COAL	LIMESTONE
Transfer receiving hoppers to bunkers	6.3 kg/s (25TPH)	6.3 kg/s (25TPH)
Bunkers - capacity	4 x 74.8 Mg (82.5 T)	2 x 68 Mg (75 T)
Transfer to Bins	1.3 kg/s (5 TPH)	0.63 kg/s (2.5TPH)
Bins - Capacity	2 x 4.5 Mg (5 T)	2 x 2.3 Mg (2.5 T)
Burn rate	0.65 kg/s (2.5TPH)	0.3 kg/s (1.13TPH)

Figure 2-4: Flow Diagram - Limestone

boiler. The bunkers have been located completely within the boilerhouse to minimize the possibility of coal freeze-up while awaiting use. Furthermore, the discharge cones are fitted with vibrating stainless steel bin dischargers to reduce the possibility of "rat-holing".

From the bin dischargers, the coal from each pair of bunkers is elevated to a ready-use bin for the associated boiler. Alternatively, by means of a transfer conveyor, shown in Figure 2-3, either ready-use bin can be replenished from either pair of bunkers. This ensures that if any one item of transfer equipment between the bunkers and the bins fails, both boilers can still be operated.

Coal is extracted from the bins at controlled rates by belt-type weigh feeders, one per boiler, and transferred by a split chute to the two stokers per boiler.

223.2 Wood Chips

It had originally been intended that a complete storage and handling system be provided so that wood chips could be used as a supplementary fuel on a continuous basis. Consideration of the overall cost of such an installation, together with uncertainties of price and long term continuous supply of wood chips for this particular plant, led to a modified approach in which the use of wood chips could be demonstrated, but they could not be fired on a continuous basis. This was done by retaining within the design the two ready-use wood chip bins above the boilers but omitting the originally-intended bulk storage and handling facilities.

223.3 Limestone

The method of handling limestone is very similar to that for coal, except that it is not intended to provide a major stockpile of limestone at the base. With limestone being brought a relatively short distance from New Brunswick, little difficulty is foreseen in delivering it directly to the plant as required.

It is intended to buy limestone sized as required for the fluidized beds. However, the possibility of having to deal with frozen lumps has been recognized, and therefore after being dumped through a "grizzly" the limestone passes through a screen and crusher arrangement similar to that for coal. It is then transferred by elevator and belt conveyor to two storage bunkers, one per boiler. Each has a capacity of 68 metric tonnes.

From the bunkers the limestone is elevated to ready-use bins, one per boiler, from which it is taken at controlled rates by two weigh feeders per boiler and fed through drop pipes into the respective fluidized beds.

As the provision of limestone is not critical for the production of steam no provision has been made to supply limestone from either bunker to the ready-use bin of the opposite boiler.

223.4 Ash Handling

A comprehensive system of ash handling is provided for the collection and storage of spent limestone and ash residue from the fluidized beds, together with fly ash collected in the baghouse filters. A pneumatic eduction system is used wherein a steam exhauster provides the vacuum. A steam exhauster was selected over a motor driven unit to reduce the requirement for electrical power.

An ash silo is provided to give storage for the ash from 68 hours of operation at maximum demand.

224 PLANT AUXILIARY SYSTEMS

224.1 Steam and Condensate Systems

The steam and condensate systems associated with the AFBC boilers are virtually self-contained and separate from those of the older stoker-fired steam Plant No. 2. There is, however, cross-connection of the main steam discharge to the base heating as well as to a common service steam manifold which is essentially for plant heating.

Both the older stoker-fired plant and the FBB demonstration plant receive condensate from the base heating systems. The hotwells of the two plants are connected by an appropriate levelling pipe. The hotwell for the FBB plant has been proportioned to accept the complete drainage of a condensate line from the higher accommodation areas of the base as well as from the area in the vicinity of Plant No. 2.

The feedwater system uses condensate pumps to move water from the hotwell to a feedwater heating deaerator. The deaerated feedwater is supplied to the boilers by boiler feed pumps, two being electrically driven for normal use, with a third being steam driven. The exhaust steam from the feed pump is supplied to the deaerator. Provision is made to circulate condensate from the hotwell through the boiler bed drain coolers and back to the hotwell to conserve heat. Feedwater make-up is taken from the base raw-water system and passed through a dual water softening unit. Chemical treatment for boiler feedwater and deaerator water is provided.

224.2 Lighting-up Fuel System

A simple system supplies No. 2 fuel oil to the lighting-up burner on each boiler and to the diesel-driven auxiliary power unit. It consists of a small storage tank situated outside the boilerhouse at grade level, with gravity flow to the diesel generator and to two transfer pumps, each of full-duty rating, which deliver oil to the boiler lighting-up burners.

225 ELECTRICAL

Considerable electrical power is required to operate the AFBC boilers and since none is normally generated at the boiler plant, it must be provided from external sources either within or outside the base. The Maritime Electric Company, Limited, supplies power to a substation local to the stoker-fired Plant No. 2. A high voltage cable connects the substation to a dry-type transformer in a motor control centre beneath the control room. Distribution is effected from the motor control centre.

A diesel-driven auxiliary power generator is situated at grade level between the two baghouses. It is sized to start up and maintain in operation either, but not both, of the fluidized bed boilers. It is always independent of the primary power supply, that is, no paralleling is required. Upon power failure it starts manually and is suitable for rapid acceptance of load. The major starting loads are those of the forced and induced draft fans.

226 BOILER DESIGN

226.1 Gas Path

A cross-sectional elevation of one of the Summerside fluidized bed boilers is shown in Figure 2-5.

The forced draft fan is situated below grade, drawing air from within the boilerhouse through an inlet silencer. The air is ducted to the base of the boiler, into a plenum below the distributor plate and forced up through its nozzles into the fluidized bed. The flue gases from the combustion zone pass through a water-cooled furnace section, then through a two-pass convection section, into a mechanical dust extractor and thence to an economizer. They are then drawn through a baghouse by an induced-draft fan and discharged to atmosphere through a free-standing stack passing through the roof of the building.

226.2 Boiler, Furnace and Pressure Parts

As shown in the cross-sectional elevation in Figure 2-5, the boiler furnace and pressure parts are suitable for shop manufacture as a package, and are an adaptation of a well-proven two-drum water-tube steam generator utilizing natural circulation throughout. The dimensions of the boiler package are such that it can be shipped by rail on a large, flat-bed rail car.

The furnace differs from that of a conventional coal or oil-fired boiler, not only in the provision for a fluidized bed, but also in that it is divided vertically by a membrane (partition) wall of tubes extending the full height of the furnace. This divides the bed into two sections arranged side by side, the partition wall being parallel to the boiler drums. The bed closest to the drums is the preferential bed, and is referred to as 'A' bed. It is in use whenever the boiler

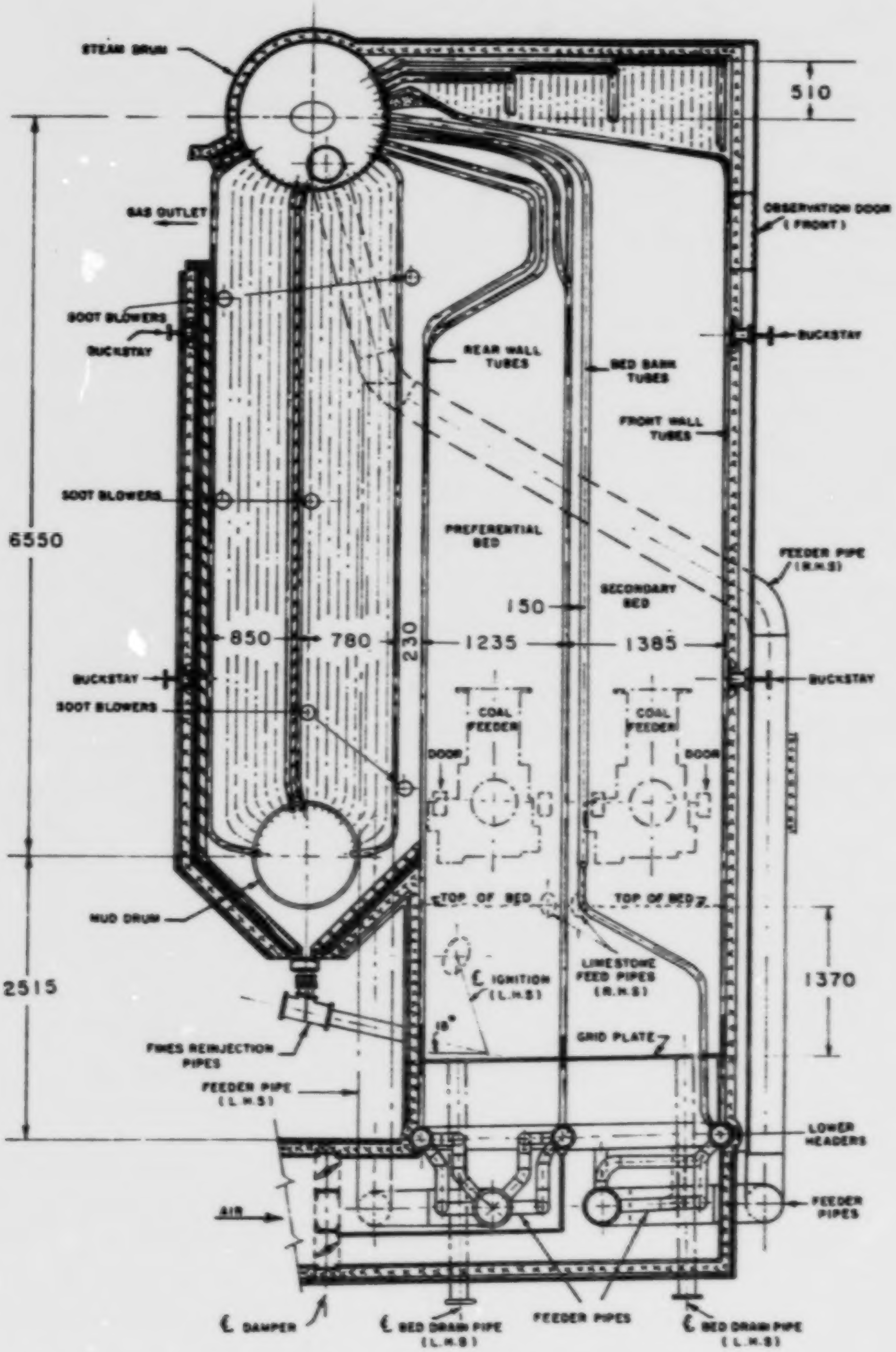

STEAM DRUM
510
6550
GAS OUTLET
OBSERVATION DOOR (FRONT)
SOOT BLOWERS
BUCKSTAY
BUCKSTAY
REAR WALL TUBES
BED BANK TUBES
FRONT WALL TUBES
SOOT BLOWERS
PREFERENTIAL BED
FEEDER PIPE (R.H.S)
SECONDARY BED
150
850
780
230
1235
1385
BUCKSTAY
BUCKSTAY
SOOT BLOWERS
COAL FEEDER
COAL FEEDER
DOOR
DOOR
TOP OF BED
TOP OF BED
MUD DRUM
LIMESTONE FEED PIPES (R.H.S)
1370
2515
℄ IGNITION (L.H.S)
18°
GRID PLATE
FINES REINJECTION PIPES
FEEDER PIPE (L.H.S)
LOWER HEADERS
AIR
FEEDER PIPES
℄ DAMPER
℄ BED DRAIN PIPE (L.H.S)
FEEDER PIPES
℄ BED DRAIN PIPE (L.H.S)

Figure 2-5: Fluidized Bed Boiler - Cross-sectional Elevation

is in operation and it is the bed in which combustion is initiated by a lighting-up burner using No. 2 fuel oil. The preferential bed contains no heat exchange surfaces other than the membrane walls which surround it. It requires virtually no refractory. In addition to coal, it receives all the wood chips to be burned, the recycled fines from the convection bank and fly ash from the mechanical dust collector.

The other bed, which is slightly larger, is called the secondary bed, or 'B' bed. It operates at a somewhat lower temperature than the preferential bed and incorporates an immersed heat transfer surface in the form of inclined tubes passing through it. As with the membrane walls these tubes are cooled by natural circulation.

Combustion air is introduced through a large number of alloy steel bubble caps (nozzles) penetrating the uncooled distributor plate which forms the floor of the furnace. The nozzles project above the distributor plate by a few centimetres and thus leave a layer of undisturbed bed material which serves to insulate the distributor plate. Each bed section is supplied with air from a separately controlled plenum.

Each bed is fed by an individual spreader stoker. These stokers distribute the coal along the length of the fluidized beds, that is, parallel to the boiler drums. With conventional boiler firing the spreader stoker, with its incorporated chain feeder, meters or controls the rate of coal discharge into the furnace. However, with the fluidized bed boilers the stokers are set to give an optimum coal distribution across the beds and control the feed rate to meet steam demand. Metering of the coal is carried out upstream by means of weigh feeders. The weigh feeder maintains the pantleg above the stoker full of coal. Incorporated in the spreader stoker which supplies the preferential bed there is a water-cooled wood-feeding spout which injects wood chips by gravity. The wood spout is provided with air jets. Wood is fed to the preferential bed only.

The limestone is admitted to each bed by a drop pipe at the end of the bed remote from the coal feeder. The drop pipe terminates at approximately the upper level of an expanded bed. The bed drains, on the other hand, are located at the coal feeder ends of the beds. Hence the limestone must traverse the entire length of the bed before reaching the discharge, thereby maximizing the residence time available for reaction. The limestone feed rate is controlled by weigh feeders upstream of the drop pipes.

The furnace cavity is tall, (approximately 8 m) and the flue gases leave at the highest point to enter the convective heat transfer zone of the boiler. The tall furnace facilitates completion of combustion and neutralization reactions as well as heat transfer.

226.3 Feed Systems for Coal, Wood and Limestone

The feed systems which are located directly on the boilers have already been described. Immediately upstream, for each boiler, coal is fed from its ready-use bin to a weigh feeder which meters the coal feed rate. It discharges to a dividing or pantleg chute which supplies coal to both of the spreader stokers on the boiler, which in turn control coal flow into the beds, as described in Section 226.2.

The ready-use bins for the wood chips are live bottom designs which discharge to one screwfeeder per boiler. Each feeder discharges to the spreader stoker on the preferential bed.

Each boiler has two weigh feeders controlling the supply of limestone, one for each of the fluidized beds. From the weigh feeders the limestone is fed directly to the respective beds through the drop pipes.

All weigh feeders are integrated into the overall boiler control system.

226.4 Carbon Recycle

Due to the highly turbulent state of the fluidized bed, there is inevitably a carryover of unburned carbon and limestone fines out of the furnace. Some of these are deposited in the hopper beneath the two-pass convection section of the boiler. A much larger quantity is trapped by the mechancial dust collector located between the boiler and the economizer. This carried over material is reinjected into the preferential bed a short distance above the distributor plate. The two streams are handled separately. Those from the hoppers beneath the boiler bank are re-injected by pneumatically-operated eductors on a continuous basis. Those from the mechanical collector are re-injected batch-wise through Permalok double gate valves and hoppers. The latter system requires less power for operation than the continuously-operated eductors, but space and height limitations precluded its use under the boiler bank.

In addition to improving carbon burn-out, and therefore boiler efficiency, the recycle system improves limestone utilization.

226.5 Bed Drain System

The bed drain system serves the dual purposes of varying the bed level in each cell to suit changing load conditions and of removing largely-spent limestone together with residual ash from the coal. As mentioned above the bed drain pipes are at the ends of the beds remote from the limestone supply pipes to give maximum residence time for the limestone. The bed drain pipes, one per bed, pass from the bed at the level of the air distributor plate down through the air inlet plenum to bed drain coolers located under the boilers.

The bed drains, one per bed, are water-cooled twin-screw conveyors driven by direct-current controllable-speed motors. The boiler control system varies the rotational speed of the screws, and thus controls the rate of extraction and the bed level. In the interests of thermal economy the bed drains are cooled by circulation of condensate which is taken from and returned to the main hotwell. Thus the heat given up in the bed drains is returned to the boiler feedwater.

The bed residue expelled from the drains passes into hoppers from which it is automatically transferred by the ash handling system to the ash storage silo for disposal.

226.6 Secondary Heat Recovery and Flue Gas Clean-up

To meet the design requirements for a maximum stack temperature of 175°C an economizer is located downstream from the mechanical dust collector. It is of finned tube design.

Final gas clean-up with respect to particulates is accomplished by means of bag filters. Each boiler has a baghouse located downstream of the mechanical dust collector and economizer. Thus the baghouse needs only to contend with relatively cool gas, laden with fine particulates. Teflon-coated bags are arranged in 12 cells of 36 filter tubes each. Cleaning is achieved by shock pulsing a reverse air flow sequentially to each cell. The dislodged fly ash accumulates in the conical hoppers beneath the filter tubes, and is removed by the pneumatic ash handling system which also serves the bed drain coolers.

226.7 Bed Light-up System

Each boiler is lighted-up by heating the preferential bed with an air-atomized light-oil-fired ignition burner provided with a propane gas pilot. The fuel oil supply system has already been described. The ignition burner is managed from a local panel which provides control and interlocking for flame proving, safety shutdown and air regulation. It is also integrated with the boiler operating panel in the control room. The ignition burner is positioned at the limestone feeder end of the preferential bed just above the slumped level of the bed, and is angled downward so that the flame impinges upon the upper surface of the bed.

227 CONTROL AND INSTRUMENTATION SYSTEMS

227.1 Control Room

As mentioned earlier part of the space between the main structures of Plant No. 2 and the new boilerhouse is used for a control room, from which all four boilers, that is, the two older stoker-fired units and the two AFBC units, are controlled and supervised.

The control room is at an elevation approximately half-way between the firing levels of the stoker-fired and AFBC boilers, with ready access both ways.

Major functions carried out from the control room include:

1. Overall supervision and control of the AFBC boilers.
2. Supervision and control of coal, wood, limestone and ash handling systems.

3. Supervision of all auxiliary systems, that is, steam, condensate and feedwater systems.
4. All recording and data-logging functions.

227.2 Control Philosophy

A centralized control philosophy has been adopted whereby the fluidized bed boilers can be started up, operated and shut down from the control room. Certain operations which are only carried out on start-up or shutdown of the boilers or which normally function automatically, are controlled from local stations outside the control room.

227.3 Fluidized Bed Boiler Controls

The control panel consists of three sections, one for each AFBC boiler, and one for common services. Each section provides centralized control, indication, recording and alarm annunciation.

Control of the boiler feedwater, air flow, coal and limestone feed, and bed level are provided by a Bailey Controls 820 Series electric analog control system. All boiler control loops are regulated by means of Bailey operator control stations located on the panel.

The following loops are provided for each boiler:

- Plant Master: To develop a demand for fuel and air flow for each boiler based on an indication of plant load. Header pressure is used as the demand signal.

- Fuel Flow: To maintain fuel flow to the beds to suit load demand and air flow and to keep bed temperatures within allowable limits. Boiler master demand, air flow, fuel flow, bed temperature and oxygen in the flue gas are used to develop the control signal for each bed.

- Air Flow: To maintain air flow in balance with load demand and fuel flow. The control signal for each bed is developed from boiler master demand, fuel flow, and oxygen in the flue gas.

- Limestone Feed and Bed Drain: For each bed, to supply sufficient limestone and to control bed drain rate to maintain the bed level within prescribed limits. The limestone feed signal is developed from fuel flow, SO_2 in the flue gas, and limestone flow. The bed drain speed is regulated by a signal developed from bed level and limestone feed.

- Feedwater Flow: To maintain feedwater flow at the same rate as steam flow and to keep the level of water in the steam drum at the desired value. A two element controller measuring steam flow and drum water level is used.

- Miscellaneous Air Flows: To maintain the forced draft fan discharge pressure and primary air flow at the required level by control of the fan inlet vanes.

- Furnace Pressure: To maintain the furnace pressure within a narrow band about a set-point value to ensure satisfactory combustion of fuel and safe unit operation. Total boiler air flow demand and furnace pressure are used to develop the signal which controls the inlet vanes of the induced draft fan.

Normally the foregoing loops are expected to function automatically, but the control stations also provide manual operation modes.

227.4 Controls for Miscellaneous Equipment and Systems

Other controls include:

- Ash Reinjection System: The ash reinjection system with its associated blowers is controlled from a panel mounted locally. It normally functions automatically and unattended.

- Wood Chip Feed Conveyor: Each boiler is provided with a screw conveyor to deliver wood chips from the wood chip storage bin to the preferential bed. The speed of the conveyor is regulated manually from an operator station in the control room.

- Ignition System: The ignition burner is controlled from a local panel which is also integrated into the control room panel so that the burner can be started up, shut down and tripped on a master fuel trip.

- Baghouse: The baghouse is provided with compressed air to pulse-clean the bags. A local panel automatically controls the pulse-cleaning sequence according to an adjustable differential pressure across the baghouse.

In general all plant common services are operated and are monitored from the control room. Exceptions are the auxiliary power unit, air compressors, water treatment system, chemical feed system, heating and ventilating system, and unloading of the ash silo, all of which are operated locally. A common services control panel in the control room provides centralized indication, recording, alarm annunciation and operation. These functions are achieved by conventional technology and therefore will not be described here.

Instrumentation is in excess of what would normally be supplied for a conventional boiler installation, in order to facilitate the testing and demonstration trials planned for the AFBC boilers.

227.5 Materials Handling Systems

In general the materials handling systems are designed to be operated from the control room. Exceptions to this are the filling of the wood bins, manual operation of isolating gates on the coal and limestone bunkers and bins, ash silo operation and coal and limestone receiving operations. All these functions are performed locally. No attempt has been made to integrate the fuel handling of Plant No. 2 with that of the AFBC boilers.

Control panels are provided in the control room for the following systems:

1. Coal handling
2. Limestone handling
3. Ash handling

The coal and limestone handling systems both consist of two sub-systems. The first transports the material in question from the receiving hopper to the storage bunkers, the second transfers the material to the appropriate ready-use bin. Each system is operated from the corresponding panel in the control room and mimic diagrams provide a convenient display of what is happening. The systems are conventional, but highly automated with interlocks and local trips.

The ash handling system can be operated entirely from the control room. The operator can manually select and unload any one of eight unloading stations, or he can program the controls to sequence automatically through the stations, in any order.

TABLE 2-1 CLIENT'S SPECIFICATIONS FOR AFBC CAPACITY AND OPERATING CONDITIONS

Full load continuous capacity		18000 kg/h (40,000 lb/h) steam
Continuous efficient capability		4000 kg/h (9,000 lb/h) steam
Steam conditions		99.9% dry saturated
Steam pressure		760 to 965 kPa (110 to 140 psig)
Feedwater temperature		105°C (221°F)
Boiler efficiency		80% minimum based on design coal at 5% moisture
Stack temperature		175°C (350°F) maximum
Availability		Minimum of three months of continuous 24 hours-a-day operation
Scheduled down time		Maximum 60 days per year
Load following capability		Adequate to meet normal variations in plant demand as identified from plant records
Fuel Flexibility		30% of heat input from wood chips at any load
Emissions	SO_2	2.96 kg/10^6 k.cal. heat input (1.64 lb/10^6 BTU heat input)
	Particulates	0.36 kg/10^6 k.cal. heat input (0.2 lb/10^6 BTU heat input)
Visible emissions		Opacity of gases emitted to ambient not to exceed 5% as determined by the Environmental Protection Service of Environment Canada

TABLE 2-2 PARTICULARS OF DESIGN COAL (DEVCO, PRINCE MINE)

Proximate Analysis		Dry Basis	Range
Moisture	%	0.0	0-10
Ash	%	19.3	16-22
Volatile Matter	%	33.5	
Fixed Carbon (by diff.)	%	47.2	
		100.0	

Ultimate Analysis		Dry Basis	Range
Carbon	%	64.2	
Hydrogen	%	4.0	
Sulphur	%	5.5	5-6
Nitrogen	%	1.0	
Ash	%	19.3	15-22
Oxygen (by diff.)		6.0	
		100.0	

Calorific Value		
MJ/kg, gross	26.7	23.2-27.7
BTU/lb, gross	11,500	9,970-11,900

Ash Fusion Temperature	Reducing	Range
Initial	1175°C (2150°F)	1100-1200°C
Softening, spherical	1305°C (2380°F)	
Softening, hemispherical	1355°C (2470°F)	1140-1375°C
Fluid	1375°C (2510°F)	1200-1400°C

Ash Analysis (Typical)

SiO_2	39.7%	Al_2O_3	25.5%	Fe_2O_3	27.0%
TiO_2	1.2%	P_2O_5	0.7%	CaO	1.0%
MgO	0.5%	SO_3	0.7%	Na_2O	2.7%
K_2O	2.3%				

Size Consist: 50 mm (2 in.) x 0 with a maximum of 20% less than 0.6 mm (28 mesh)

TABLE 2-3 PARTICULARS OF SUPPLEMENTARY FUEL (WOOD CHIPS)

Ultimate Analysis		Dry Basis	Range
Carbon	%	49.5	
Hydrogen	%	6.0	
Oxygen	%	42.0	
Nitrogen	%	1.0	
Ash	%	1.5	0.5-3.0
Moisture	%	0.0	30-60
		100.0	

Calorific Value		
MJ/kg, gross	20.2	8.1-14.2 (as fired)
BTU/lb, gross	8,700	3,480-6,090

The wood chips would be a mixture of hardwood and softwood from a tree chipper, giving a size consist of: 25 mm (1 in. x 0) but including twigs up to 50 cm (20 in.) long.

PARTICULARS OF DEMONSTRATION FUEL
(LOW GRADE COAL AND WASHERY REJECTS)

Proximate Analysis	
Ash	40% maximum
Moisture	12% maximum
Sulphur	9% maximum

Calorific Value	
MJ/kg, gross	20.2
BTU/lb, gross	8,700

Ash Fusion Temperature, Initial 1000°C (1832°F) minimum.

Size Consist: 50 mm (2 in.) x 0 with a maximum of 40% less than 0.6 mm (28 mesh)

TABLE 2-4 PARTICULARS OF DESIGN LIMESTONE
(HAVELOCK LIME WORKS LTD., HAVELOCK, NEW BRUNSWICK)

	As Element, %	As Oxide, %
Loss on ignition at 1800°F	42.60	42.60
Si (SiO_2)	0.63	1.35
Al (Al_2O_3)	0.08	0.15
Fe (Fe_2O_3)	0.12	0.17
Ca (CaO)	39.52	55.33
Mg (MgO)	0.41	0.08
S	0.01	
Total	83.37	100.28

Estimated Ca present as CaO + $Ca(OH)_2$:	0.05%
Estimated Mg present as MgO + $Mg(OH)_2$:	0.01%
Estimated Ca present as $CaSO_4$, assuming all S present as $CaSO_4$:	0.17%

The above indicates the Design Limestone as being approximately 98% $CaCO_3$.

TABLE 2-5 PLANT DESIGN DATA

These data are the supplier's predicted performance per boiler operating at 100% MCR.

Steam flow	kg/h	18,150
Outlet pressure	kPa	965
Outlet temperature	°C	182
Feedwater temperature	°C	105
Boiler blowdown rate	kg/h	250
Coal feed rate	kg/h	2,210
Limestone feed rate	kg/h	1,019
Combustion air flow	kg/h	21,150
Total air side loss	mmH_2O	1,455
Total gas side loss	mmH_2O	310
Particulate emissions	$kg/10^6k.cal.$	0.216
SO_2 emissions	$kg/10^6k.cal.$	2.52
NO_x emissions	$kg/10^6k.cal.$	2.16
Stack temperature	°C	176
Boiler efficiency (ASME)	%	81.6
F.D. Fan H.P.		221
I.D. Fan H.P.		92.8
Excess air	%	22
Bed dimensions	m	1.23 x 2.88
Operating temperature	°C	885
Fluidizing velocity	m/sec	2.4
Ca/S Ratio		3:1
Expanded depth	m	1.37
Turndown ratio		4.5:1

TABLE 2-6 DATA ON ELECTRICAL REQUIREMENTS

The figures given are for two boilers in operation at 100% MCR.

	Connected Load kW	Maximum Motor kW
Coal handling	85	20
Limestone handling	71	15
Woodchip handling	14	5
Boiler and draft system	850	300
Oil fuel and water system	45	40
Ash handling	195	50
Building services	32	10
Compressors	50	25
TOTALS	1,328	

Nominal consumption for 2 boilers at MCR.	690 kW
Auxiliary Power Unit	620 kW

2.3 SOURCES OF DATA AND ACKNOWLEDGEMENTS

231 SOURCES OF DATA

Information for this report has been obtained from the following sources, and extracts from them have, on occasion, been quoted verbatim. Drawings, sketches, schematics from these sources have also been duplicated, sometimes with change in title or figure number.

- Foster Wheeler Limited, St. Catharines, Ontario, Canada.

- Defence Canada, in particular the Base and Plant personnel at Summerside.

- Energy, Mines and Resources Canada.

- A paper entitled "Improving the Performance of Fluidized Bed Boilers at Canadian Forces Base Summerside" presented by V.V. Razbin and F.D. Friedrich of CANMET/ERL of Energy, Mines and Resources Canada at an EPRI Seminar on AFB Technology for Utility Applications, held in Palo Alto, California, 8-10 April 1986.

- A paper entitled "The CFB Summerside Project: Canadian State-of-the-Art in AFBC Boilers" by M.E.D. Taylor of Monenco Consultants Limited and F.D. Friedrich of CANMET, Energy, Mines and Resources Canada, April 1982.

232 ACKNOWLEDGEMENTS

Monenco acknowledges with thanks its indebtedness to Messrs. Frank Friedrich and Vladimir Razbin of EM&R and Messrs. Peter Adams, Bill Tanner and Don Duncan of FWL for their reviews of the draft report and their valuable commentary on it; to Messrs. Emmett Kelly and Ed Laughlin for the data they developed and the information they provided for this report. The photographs reproduced in colour in Part 5 were taken by Mr. Razbin. Some of the Figures in this report are reproduced by courtesy of the authors from a paper presented by Mr. V.V. Razbin and Mr. F.D. Friedrich at an EPRI Seminar in Palo Alto, detailed above.

PART 3

FURNACE TUBE EROSION

3.1 ANALYSIS OF EROSION AND THE VARIOUS REMEDIAL MEASURES ADOPTED

311 INITIAL OPERATION AND EARLY DETECTION OF TUBE EROSION (December 1982 to February 1983)

311.1 Initial Operation

Events, during initial operation, which led to an early discovery of tube polishing and minor erosion, are briefly related below:

November 1982

Boil-out was completed on both Fluidized Bed Boilers between 24 and 27 November 1982.

December 1982

Initial attempts to start-up FBB-1 were met by a variety of problems which frustrated stable operation. These problems included the following:

- Difficulty in fluidizing 'A' bed on cold start-up.
- Destruction of thermocouples and thermowells due to overheating by the ignition burner during start-up.
- Leakage of bed material at the perimeter seals of the distributor plate, in particular at the membrane wall near the bed transfer gate.

- Blockage of reinjection nozzles with limestone.

- Fuel feed problems in the coal storage and handling system.

- Stoker stalls.

FBB-1/A was successfully fluidized for the first time on 12 December 1982, and first steam was generated around midnight of that day. However, at 08:30 hours next morning the boiler was shut down briefly in order to seal leakage at the distributor plate periphery. It was restarted after temporary repair, but had to be shut down at the end of the day, on 13 December 1982, because of continuing leakage at the distributor plate seal.

January 1983

FBB-1/A was restarted on 5 January 1983 and a steam flow of 5.8 Mg/h was established on the next day, 6 January 1983.

FBB-1/A was operated from 6 to 11 January and again from 19 to 26 January 1983. FBB-1/B was operated on 9, 10 and 11 January only.

The shut down on 11 January was, in the main, caused by clinker formation following upon mains power supply failure. The shutdown on 26 January resulted from a combination of reinjection system problems and clinker formation.

311.2 Early Erosion Detection

The first mention of erosion is recorded on 29 January 1983, when FBB-1/A was inspected, and it was seen that the drum wall tubes in the area above the distributor plate were polished, particularly in the vicinity of the bed drain.

It had already been noted that the perimeter of the bed is more active than the centre. It was later determined that the perimeter turbulence was wearing away the upper faces of tube weld projections. This was attributed to a downward washing action by perimeter turbulence. However, tube thickness measurements indicated greater tube metal wastage below the weld than above it.

312 CONCLUSIONS DRAWN FROM EVIDENCE AND REMEDIAL MEASURES PLANNED (February and March 1983)

312.1 Conclusions Drawn

The conclusions drawn from the evidence of wear seen in FBB-1/A were as follows:

- High perimeter turbulence of the fluidized bed is causing metal wastage.
- The area of wastage appears to be restricted to a 24 in. high horizontal band around the membrane walls of each bed, ranging from 24 in. to 48 in. above the distributor plate.
- The erosive action of the fluidized bed also wears away the reinjection nozzles entering the bed above the distributor plate.
- The erosive action wears the original refractory installed to protect the surface below the coal stokers.

312.2 Remedial Measures Planned

Based on the conclusions drawn, a mix of remedial measures was planned. FWL reviewed these measures in relation to their experience of fluidized bed boiler operation in the United States and Europe and submitted proposals which were agreed upon with DCL.

The remedial action planned took two main forms:

- Additional peripheral nozzles in the distributor plate were recommended in order to counter the downward washing action of bed turbulence which appeared to be a major cause of membrane erosion in the fluidized bed zone.

- Application of Lavalox refractory along a 24 in. high band running horizontally around the surface of the membrane wall, covering a zone from 24 in. to 48 in. above the distributor plate.

In recognition of the fact that, to a certain extent, the two measures covered the same territory, it was decided to install the peripheral nozzles in FBB-2/A, and determine their effectiveness by running the bed before applying Lavalox. Meanwhile Lavalox application would commence in FBB-1.

312.3 Selection of Refractory

There was some debate about the selection of refractory to be used for lining the waterwalls. The choice lay between Lavalox and Silicon Carbide. The relative merits of the two were set down as follows:

- Lavalox (No. B108) is a phosphate bonded mix, chemically set, which is prepared in small quantities and manually trowelled onto a mesh of interwoven spiraled No. 310, 16 gauge, stainless steel wire. The spirals of half-inch diameter are anchored by tying onto Nelson studs which, in turn, are welded at 100 mm centres to the fins (membrane) of the waterwalls and not to the tubes. Lavalox is supplied by the Laval Crucible Company of Pittsburg, Pennsylvania. It has a higher conductivity (14 as compared with 6) than regular refractory and was expected, therefore, to provide reasonably good heat tranfer. It was calculated that the application of Lavalox would result in a 15% downrating in capacity while maintaining bed temperatures adequate for satisfactory sulphur recovery. However, since the boiler had demostrated its ability to generate a higher than specified capacity, this downrating was considered acceptable.

- Silicon Carbide castable refractory (No. 11L1, rated to 2700°C) supplied by the Carborundum Company of Keasby, New Jersey, has a higher conductivity than Lavalox and would consequently require less downrating of the boiler. Silicon Carbide has abrasion resistance equal to Lavalox and could be expected to protect the tubes equally well. The major disadvantage of Silicon Carbide appeared to be that it is a castable refractory requiring 240 ball studs to be welded onto each square foot of waterwall surface for holding the refractory. It was considered that the mechanics of installing such a vast number of studs both on the membranes and tubes were too complex. Besides, the installation of a uniform 1/2 in. layer of castable refractory on membranes and tubes alike would not be possible, with the result that the membrane (fin) would have 1-1/2 in. of refractory and the tubes would have a 1/2 in. thickness. This uneveness in the case of a castable refractory was not considered advisable. Also, it is considered that under certain conditions Silicon Carbide is fluxed by highly ferrous ash.

On the balance, the decision favoured Lavalox.

Lavalox was also used to protect the area below the stokers and around the ignitor opening. Ash reinjection nozzles entering the furnace were also to be protected by refractory.

312.4 Perimeter Nozzles

With regard to perimeter aeration, it was agreed to add the following nozzles to FBB-2:

- Eighteen (18) 3/4 in. aerating nozzles to be added to the perimeter of the distributor plate in Bed 'A'.
- Twelve (12) 3/4 in. and six (6) 1-1/4 in. nozzles to be added to the perimeter of the distributor plate in Bed 'B'.

All 1-1/4 in. nozzles would consist of tees, 45° elbows, and piping, all of 304L stainless steel. The remaining 3/4 in. nozzles were the standard tee-nozzles employed for the rest of the bed.

313 EXECUTION OF THE PLANNED REMEDIAL MEASURES AND ANALYSIS OF THE RESULTS ACHIEVED

313.1 Perimeter Nozzles Installed in FBB-2 (83/02/28 - 83/03/05)

Since it had been decided to test the effectiveness of adding perimeter nozzles on FBB-2, the work was carried out between 28 February and 5 March 1983, prior to starting up the boiler.

In the case of FBB-2, unlike FBB-1, tube thickness measurements were taken prior to commissioning the boiler. These measurements were taken on 1 March 1983 (see Tables 3-1, 3-15, 3-18, 3-21, 3-23, 3-25, 3-28, 3-31 and 3-33).

FBB-2/A was then operated continuously for 17 days (8 to 26 March 1983) and tube thickness measurements were taken again (see Tables 3-1, 3-35, 3-36, 3-37 and 3-38).

It is clear that the results were mixed. A comparison of figures in the tables indicates that the period of operation was too brief for significant measurable wastage, although at some locations tube wall thickness does appear to have been reduced.

The visual inspection, however, revealed evidence of polishing and wastage of metal at welds. A report of the FWL supervisor, Mr. L. MacDonald states:

28 March 1983

> "Inspected Bed 'A' in Unit 2. Visually the erosion looked worse than Unit 1 with 3 tube welds being eroded, where there was virtually no weld bead left above the surface of the tubes. Again it looked as if the tube had eroded from the top as in Unit 1, but thickness measurements showed there is more metal loss below the weld than above the weld."

An extract from the minutes of a DCL-FWL meeting in Ottawa on 5 May 1983 is quoted below:

> "Item 3: Boiler Tube Erosion
>
> a) Effect of air curtain nozzles in #2 boiler was not positive. Polishing still occurred.
>
> b) Grid nozzles along the partition wall creating holes and lift and allowing limestone leakage were modified by plugging the nozzles next to the sealing stainless steel flashing."

On the other hand a field report of the FWL supervisor L. MacDonald (dated 27 March 1983) states that the perimeter nozzles appeared to have beneficially affected the refractory under the coal stoker, which showed no sign of erosion after 17 days operation. In FBB-1, on the other hand, the refractory in the same area was badly eroded after 22 days of operation.

On the whole, it was considered that the installation of perimeter nozzles in FBB-2 was not altogether successful and it was decided to proceed with Lavalox application in FBB-2 as well as in FBB-1.

313.2 Lavalox Application in FBB-1 and FBB-2

Lavalox refractory was applied in FBB-1 after sandblasting the membrane walls, and the time-scale of the work per boiler is indicated by the following schedule:

-	Fabrication of S.S. mesh	3-4 days
-	Sandblasting	1 day
-	Welding Nelson studs	2 days
-	Installing mesh (tying to studs)	2 days
-	Trowelling Lavalox on mesh	2 days

Lavalox Application in FBB-1

Lavalox application in FBB-1 was carried out between 10 March and 27 March 1983.

See Figures 3-2 and 3-3 and Photographs 4, 17, 33 in Part 5.

Lavalox Application in FBB-2

Lavalox application in FBB-2 was carried out between 11 April 1983 and 28 April 1983.

See Figures 3-2 and 3-3 and Photographs 4, 17, 33 in Part 5.

313.3 Analysis of the Physical Performance and Progressive Condition of the Lavalox Refractory

The Lavalox refractory applied to FBB-1 and FBB-2 satisfactorily performed its function of protecting the membrane walls from further erosion in the area in which it was applied. It was, however, subject to physical failure. Pieces of it could, and did, part from the main body, fall into the bed and end up in the bed drains.

The following extracts from plant logs give a picture of the physical condition of the Lavalox on a chronological basis:

Reports on Condition of Lavalox in FBB-1

83/12/22

The refractory seal at the reinjection nozzles is eroded. This has exposed the back of the scallop bar which should now be re-anchored and faced with Lavalox.

84/08/06

The following report was submitted by Mr. L. MacDonald after inspecting the Lavalox refractory in FBB-1:

FBB-1/A Drum Wall - This wall is fully intact, but shows surface glazing. The top of the material is tight to the tubes. The bottom edge has lifted away from the tubes by 1/2 in.

FBB-1/A Partition Wall - This wall is fully intact, but shows surface glazing. The top of the material is tight to the tubes. The bottom edge has lifted away from the tubes by 3/4 in.

FBB-1/A Stoker Wall - This wall is fully intact, but shows surface glazing. The top and bottom edges of the material are tight to the tubes.

FBB-1/A Sorbent Injection Wall - This wall is fully intact, but shows surface glazing. This wall has the ignitor opening and, on the partition wall side of the ignitor, the vertical edge of the material has lifted 1 in. away from the wall. (There are no anchors in this area.) Also, for 8 in. towards the partition wall from this vertical edge, at the top and bottom edge, the material has lifted 1 in. away from the wall.

FBB-1/B Partition Wall - There are two bulges in the refractory lining on this wall. There is one at a point 16 in. from the left hand sidewall which is only 3 in. wide and extends from the lower edge of the material to 8 in. above the lower edge. The centre of the other bulge is 46 in. from the left hand sidewall and is 8 in. wide. It extends from the lower edge of the material to a point 8 in. above the lower edge. Both of the bulges are bulged out to a maximum of 1 in. from the tubes. Along the rest of the lower edge of the material there is a 1/2 in. space between tubes and the material. The top edge of the material is tight to the tubes.

FBB-1/B Front Wall - This wall is fully intact, and shows surface glazing. The top and bottom edges of the material are tight to the tubes.

FBB-1/B Stoker Wall - There is a section on this wall that has spalled to expose the reinforcing mesh. This is located 18 in. from the front wall and is 2 in. wide and extends from the bottom edge of the material to 8 in. from the bottom. The lower edge of the material has lifted 1/2 in. away from the tubes. The top edge is tight to tubes.

FBB-1/B Sorbent Injection Wall - At a point 8 in. from the partition wall on the upper edge of the material, there is a 3 in. square section which has lifted 1-1/2 in. away from the wall at the edge of the limestone pipe.

There is also a section 4 in. wide by 4 in. high located 8 in. from the front wall on the lower edge of the material which is bulged away from the tubes by 1 in. The balance of the top and bottom edges of the material are tight to the tubes.

In whole, the Lavalox material is in good condition. The minor bulging that has taken place is most likely caused by missing anchors. The lifting of the lower edges of the Lavalox is most likely due to there being more overlap of reinforcing and Lavalox from the constraints of the anchor pins in this area.

The areas affected are small and intact. The purpose of identifying each area in this report is to monitor any progression of Lavalox movement that might take place.

Reports on Physical Condition of Lavalox in FBB-2

83/06/02

Lavalox has bulged as much as 3 in. away from walls. It is now attached only at top and bottom; but it does not appear to be breaking. A 1/4 in. coating of reddish material has formed on the surface of the Lavalox but it (the coating) seems to break off easily.

83/12/08

The refractory in FBB-2 has failed. The boiler has been shut down to prevent damage to tubes and bed drain. Material has been ordered for complete replacement of the Lavalox in FBB-2.

84/02/28

Pieces of Lavalox up to 6 in. in size have fallen into the bed.

84/03/16

While draining the bed material from FBB-2 it could be seen that the Lavalox in 'A' bed has failed. The Lavalox at the ignitor end is gone leaving only the mesh while Lavalox at the stoker end is half gone. The sides have large areas where the Lavalox has fallen out. Checked with St. Catharines and found out this Lavalox was old left over material that required twice as much water to get the right consistency. Three peripheral nozzles at the ignitor end are also worn out from air and bed material directed at them by the 'T' nozzles.

84/03/19

Commenced removal of Lavalox in bed 'A'.

84/03/20

Half the Lavalox in bed 'A' has been replaced. A 2 ft. section of Lavalox is still in good condition and does not need replacing.

84/03/21

All defective Lavalox replacement has been completed.

84/04/18

Inspected FBB-2/A. New Lavalox is in good shape except for that directly under the stoker. It looks like a 1/8 in. thick layer is peeling off. However, the mesh isn't exposed so there should not be a problem.

84/03/29

During the start yesterday it appeared that a 6 in. patch of new Lavalox had "bubbled" up in FBB-2. One piece has fallen away revealing that the problem is only a thin outer layer, as if they had gone back over and smoothed a thin layer on top of some already hardened material.

84/08/06

There is glazing on, but no visible damage, to the refractory in FBB-2. This report may be compared with a report of the same date on FBB-1 given above.

313.4 Other Effects of the Application of Lavalox Refractory

The progressive physical condition of the Lavalox refractory has been described in the previous section. One fact which emerges clearly from the chronological reporting is the progressive movement (bulging) of the main body of the refractory, presumably along with the mesh, away from the waterwall on which it was initially trowelled. This parting (bulging away) of the material from the heat transfer surface obviously left an air/gas gap so that, despite the vaunted conductivity of the Lavalox, heat transfer was certainly much reduced, if not altogether eliminated in this area where the fluidized bed should have interacted in heat exchange with the metal of the waterwalls (see Photograph 33 in Part 5).

A consequence of this total loss of heat transfer surface became evident in boiler performance. The air to fuel ratio had to be greatly increased in order to control the bed temperature, thereby increasing air velocity and bed turbulence. This had other consequences such as greater elutriation, increased reinjection and increased loading on the baghouse.

The waterwall section below the area of Lavalox application showed greater evidence of erosion than it had done prior to the application of Lavalox. This presumably resulted from a combination of causes. One cause could have been the change in the pattern of turbulence consequent upon the thickness of refractory lining applied 24 in. above the distributor plate. The bare area below the refractory was thus subjected to a more severe washing action as a result of a combination of change in the flow pattern and an increased turbulence due to the higher percentage of excess air. High erosion thus resulted in the area immediately below the Lavalox refractory lining.

One example of tube wear which rather dramatically highlights the problems associated with protecting boiler pressure parts by the application of refractory and sheds (scalloped bars) is given below:

The following extracts from the boiler log of Mr. L. MacDonald of FWL describes the discovery of a tube leak:

85/02/13

A pinhole tube leak was discovered about 6 in. below the Lavalox when FBB-2 was shut down for replacement of a broken bed thermocouple.

85/02/14

The tube that failed is the third tube from the rear wall on the L.H. side wall in FBB-2/A. The failure is 22 in. above the grid plate scalloped bar on the lower bend where the tubes form the ignitor opening. This bend section is not protected by refractory.

To repair the unit the six (6) lower bends at the ignitor should be replaced and the upper and lower bends encased in Lavalox.

Subsequent to this report the following action was planned, and later executed.

- The six (6) bent tubes forming the ignitor opening were removed from the furnace side of the unit with as little refractory removal as possible.

- Cutting and preparing of existing tubes to match tube sections was done using saws and grinders only, with great care being taken so that waste was not allowed to drop into cut tubes.

- The bent tube sections were replaced and the refractory ignitor throat replaced with Lavalox material.

- The tube bends in the area where erosion had taken place, were protected by a 0.5 in. thick covering of Lavalox reinforced with 0.5 in. diameter stainless steel wire coils to cover the area. Lavalox was feathered into the ignitor throat.

Photograph 9 in Part 5 of this report shows the defective tube surrounded by refractory. A shed (scalloped bar) is also seen in the picture below the tube.

314 ADDITIONAL MEASURES (SHEDS) TO COUNTERACT SPECIFIC PROBLEMS ARISING FROM THE EXECUTED CHANGES

It has been described above that as a result of Lavalox application, more severe erosion was experienced in the area between the distributor plate and the lower edge of the refractory lining. The section most seriously affected was the area immediately below the lower edge of the refractory lining.

In order to protect the bare tubes below the refractory lining it was decided to weld bars, scalloped to accommodate the semi-circles of the tubes, and inclined at 45° angled downward away from the waterwall. Four (4) horizontal rows of sheds were tack welded to the fins.

See Figure 3-3 and Photographs 6, 7 and 8.

The installation of sheds was carried out in August 1984. They covered an area approximately 15 in. below the lower edge of the Lavalox lining.

The installation of sheds once again changed the heat transfer surface and the perimeter flow pattern of the fluidized bed below the Lavalox lining. Considerable wear was evidenced in specific areas, along with polishing of the tubes in other areas between the sheds. The erosion was severe enough to wear off and break away the sheds in some locations.

See Figure 3-4 and Photographs 6, 7 and 8.

315 EROSION OF IN-BED TUBES AND THE SUCCESS OF MEASURES TO PROTECT THEM

Figure 3-1 shows the sloping in-bed tubes, inclined at 30° to the horizontal, which provide additional heat transfer surface and are located within the body of the fluidized Bed 'B' of each boiler. These eighteen (18) tubes, passing through the bed are cooled by natural circulation and slope downward from the partition wall to the front wall.

The in-bed tubes are subject to severe erosion due to the turbulent activity of bed particles, and it was discovered that their protective alonizing spalled very quickly under the erosive action to which they were subjected. These tubes are constructed of SA-210-A1 high strength carbon steel, with an outside diameter of 2.25 in. and a minimum wall thickness of 0.260 in.

Once the hard alonized layer spalled, the parent metal wasted more rapidly, particularly as a result of the more severe perimeter turbulence created by the perimeter nozzles, which wore away the material on the inside surface of the lower bend.

Photographs 5, 18, 19 and 20 show both the effect of spalling of the alonized layer and the wear on the lower surface of the tube which seriously reduced the cross-sectional wall thickness.

In order to control further erosion of in-bed tubes, rods were welded lengthwise parallel to the axis of the tubes. See Figure 3-5 and Photographs 21, 22, 23, 27 and 36.

These measures appear to have effectively controlled erosion of in-bed tubes which, apart from some minor polishing (on tubes and on the rods), appear not to have eroded further after the rods were installed.

It will be noted from Photograph 20 that some tubes had wasted to such an extent that a hole burned through the wall during the welding of the rod, consequently a section of tube was replaced.

316 STUDDING THE WATERWALLS

By the end of the 1984-85 heating season it had become fairly clear that all the remedial measures attempted up to then had failed to protect the waterwalls in the fluidized bed zone. None of them had proved to be reliable, long-lived, low-maintenance remedies. In fact the Lavalox refractory had resulted in downrating the boiler, and required an increase in the percentage of excess air for normal operation.

It was therefore decided to stud the vertical membrane wall tube surfaces. The orientation of studs is shown in Figure 3-6. These pin studs measuring 3/8 in. in diameter and 3/4 in. in length were spot-welded from the level of the scalloped bar shown in Figure 3-2 (about 2 in. above the distributor plate) to a height of 60 in. above the distributor plate. In the cross-section they were alternately oriented at 10, 12 and 2 o'clock and at 11 and 1 o'clock as seen in Photographs 11 through 16 in Part 5.

Studding of the waterwalls was carried out in the Summer of 1985 and, although one heating season is not enough for a final judgement on the results achieved, there is reason to hope that tube erosion has been halted and the boiler may now look forward to a normal life span.

The following extract from a paper by V.V. Razbin and F.F. Friedrich, presented in April 1986 at an EPRI Seminar in Palo Alto, on "AFBC Technology for Utility Application", summarizes the situation:

> "Boiler No. 2 resumed service in September 1985. It was found that replacement of the refractory with the pin studs substantially improved heat transfer, as evidenced by an increase of almost 50% in boiler capacity, and a reduction in excess air to the 50-60% range (down from 80%-90% with the refractory). An inspection after 2,500 h of operation revealed that none of the tube surfaces showed any signs of polishing; instead they were covered with a thin, black carbonaceous deposit. Some of the studs had rounded tips whereas others were capped with a partially-sintered deposit of ash. Substantial quantities of gravel-sized shale particles were trapped between the studs in a band 380 to 890 mm (15 in. to 35 in.) above the distributor plate. The in-bed tubes likewise revealed no wastage beyond some polishing of the protective rods.
>
> Another inspection in March 1986, after a further 2000 h of operation, showed conditions to be substantially unchanged."

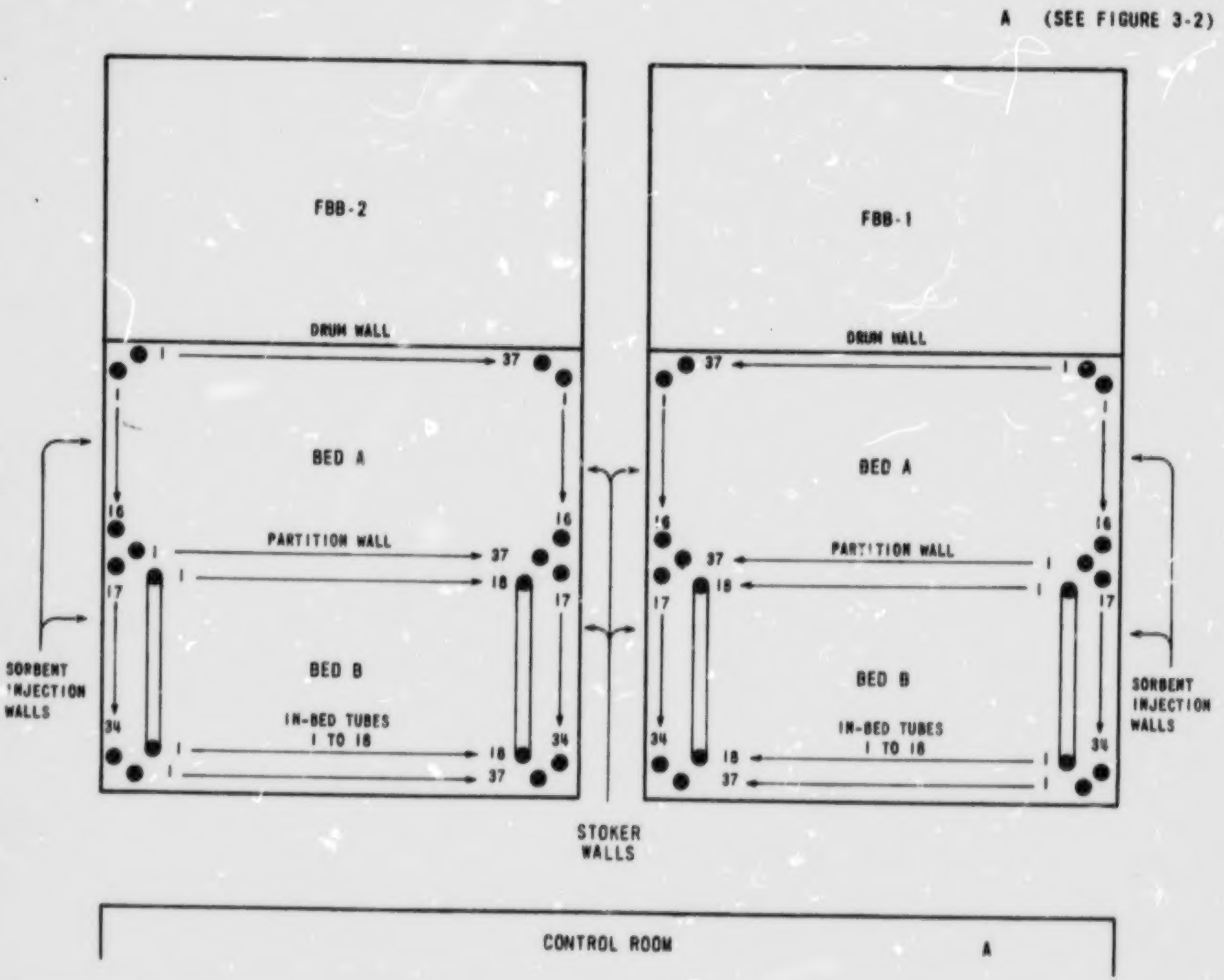

A (SEE FIGURE 3-2)
FBB-2
DRUM WALL
BED A
PARTITION WALL
BED B
IN-BED TUBES 1 TO 18
SORBENT INJECTION WALLS
1
37
16
17
34
18
STOKER WALLS
FBB-1
DRUM WALL
BED A
PARTITION WALL
BED B
IN-BED TUBES 1 TO 18
SORBENT INJECTION WALLS
CONTROL ROOM
A

FIGURE 3-1

NUMBERING OF WATER-WALL AND IN-BED TUBES IN FBB-1 AND FBB-2 (NTS)

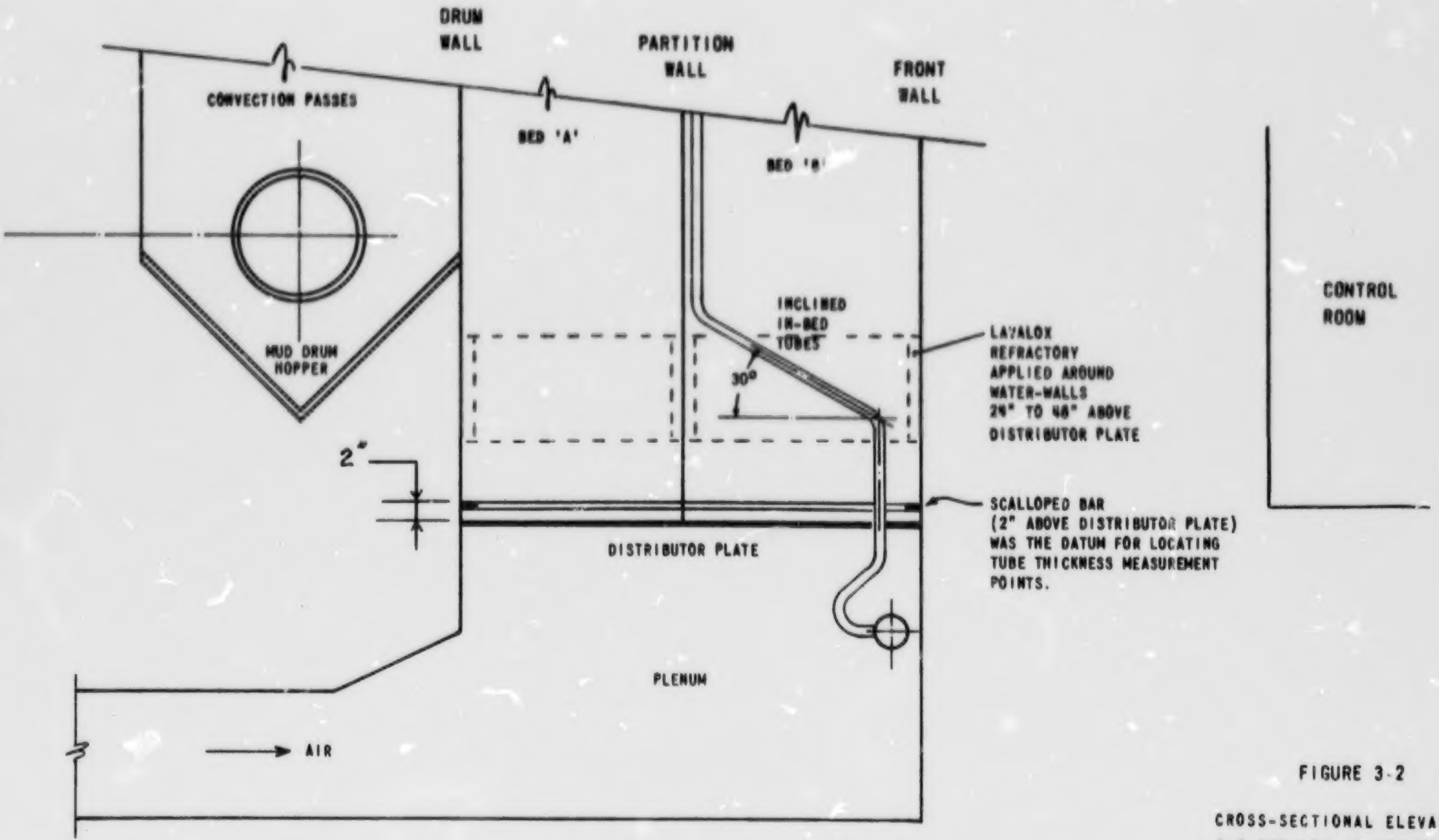
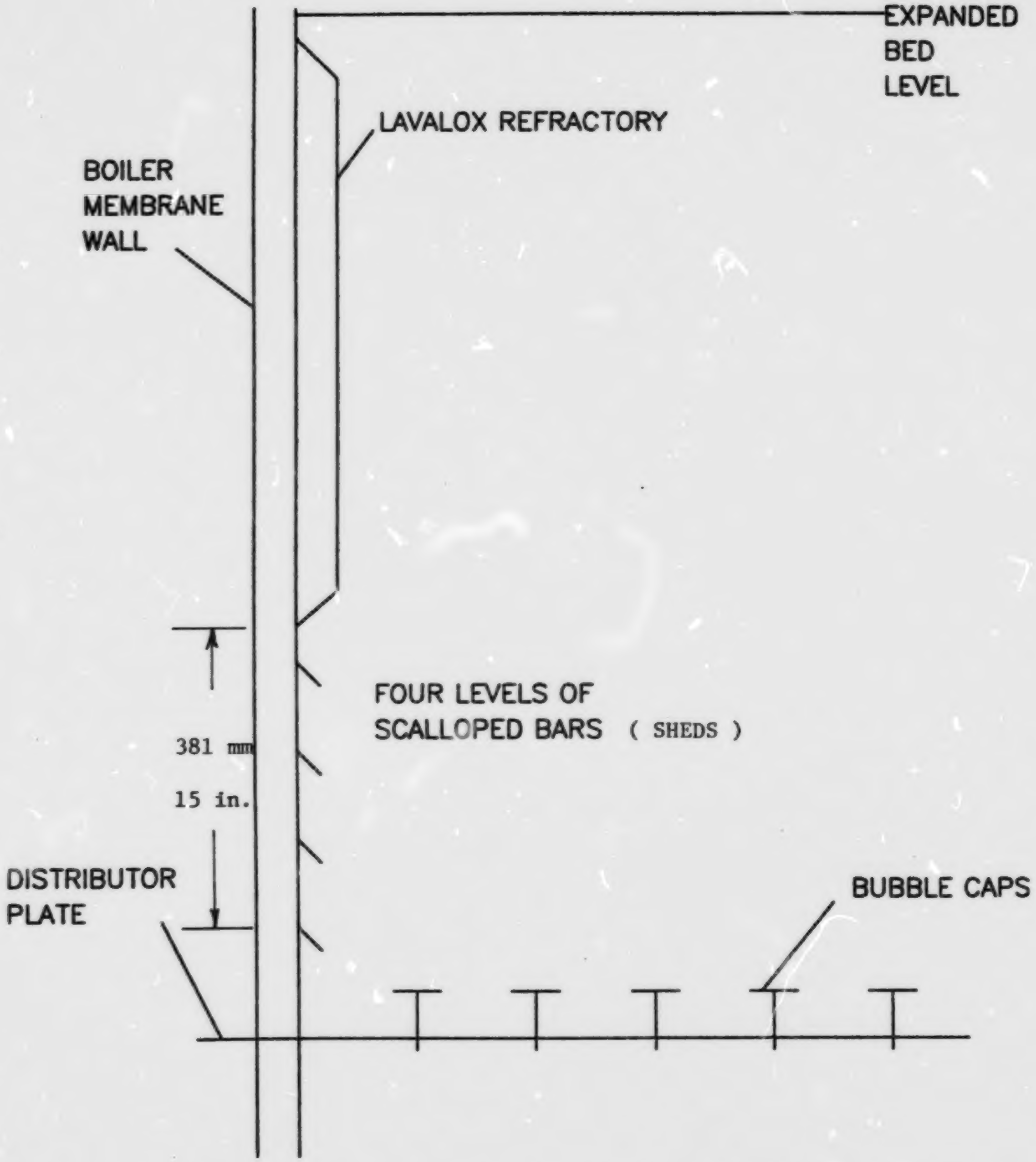

DRUM WALL
PARTITION WALL
FRONT WALL
CONVECTION PASSES
BED 'A'
BED 'B'
MUD DRUM HOPPER
INCLINED IN-BED TUBES
30°
LAVALOX REFRACTORY APPLIED AROUND WATER-WALLS 24" TO 48" ABOVE DISTRIBUTOR PLATE
CONTROL ROOM
2"
SCALLOPED BAR (2" ABOVE DISTRIBUTOR PLATE) WAS THE DATUM FOR LOCATING TUBE THICKNESS MEASUREMENT POINTS.
DISTRIBUTOR PLATE
PLENUM
AIR
SECTION A-A

FIGURE 3-2

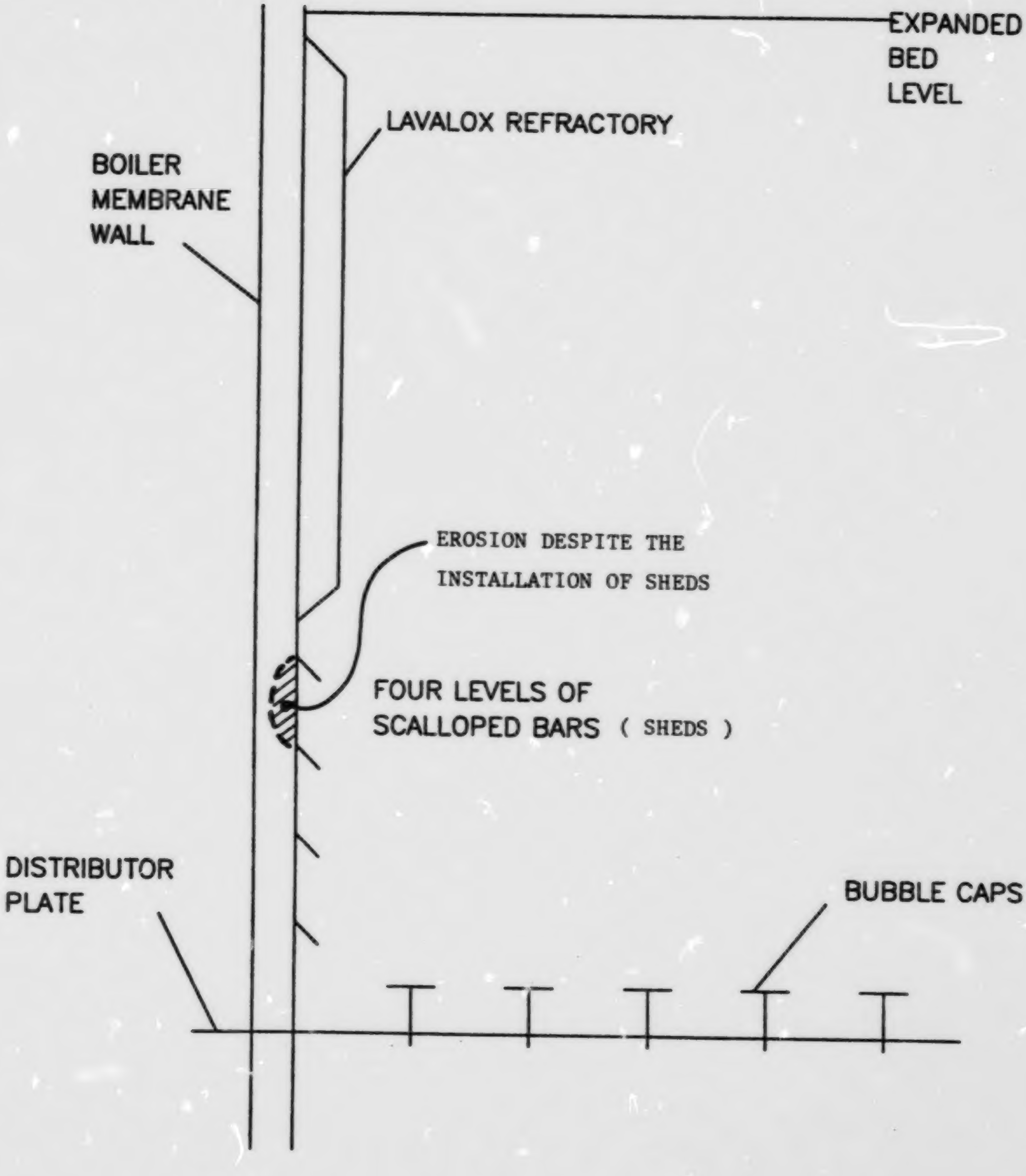
CROSS-SECTIONAL ELEVATION
A-A SHOWING IN-BED TUBES
(NTS)


EXPANDED BED LEVEL
LAVALOX REFRACTORY
BOILER MEMBRANE WALL
FOUR LEVELS OF SCALLOPED BARS (SHEDS)
381 mm
15 in.
DISTRIBUTOR PLATE
BUBBLE CAPS

Schematic of refractory and scalloped bars applied to membrane walls

Figure 3-3

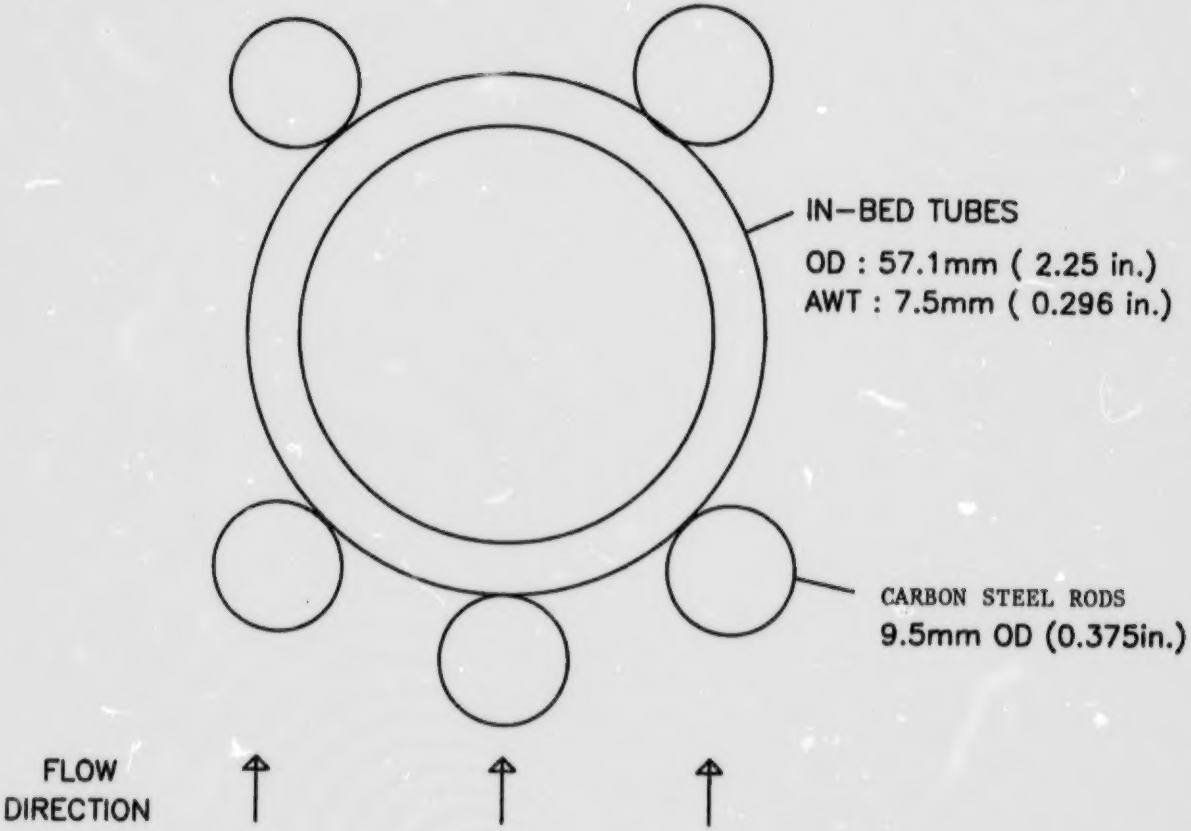
(Courtesy Friedrich/Razbin, EM&R)


EXPANDED
BED
LEVEL
LAVALOX REFRACTORY
BOILER
MEMBRANE
WALL
EROSION DESPITE THE
INSTALLATION OF SHEDS
FOUR LEVELS OF
SCALLOPED BARS (SHEDS)
DISTRIBUTOR
PLATE
BUBBLE CAPS

Erosion Despite the Scalloped Bars (Sheds)

Figure 3-4

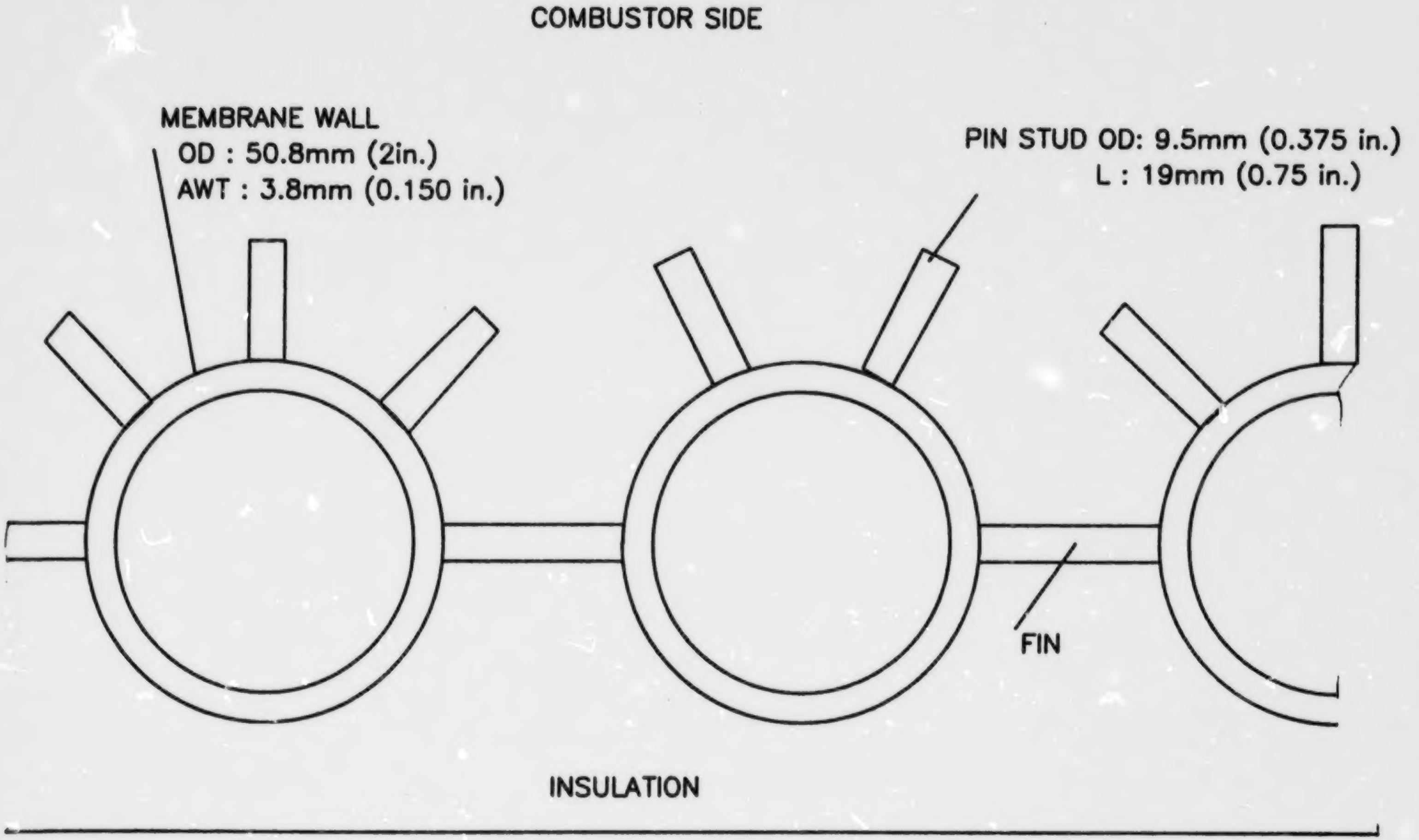
(Courtesy Friedrich/Razbin, EM&R)


IN–BED TUBES
OD : 57.1mm (2.25 in.)
AWT : 7.5mm (0.296 in.)
CARBON STEEL RODS
9.5mm OD (0.375in.)
FLOW DIRECTION

Orientation of the carbon steel rods applied to the in–bed tubes

Figure 3-5

(Courtesy Friedrich/Razbin, EM&R)


COMBUSTOR SIDE
MEMBRANE WALL
OD : 50.8mm (2in.)
AWT : 3.8mm (0.150 in.)
PIN STUD OD: 9.5mm (0.375 in.)
L : 19mm (0.75 in.)
FIN
INSULATION

Orientation of the pin studs on the membrane wall tubes

Figure 3-6

(Courtesy Friedrich/Razbin, EM&R)

3.2 TUBE THICKNESS MEASUREMENT PROGRAM

321 FREQUENCY OF TUBE THICKNESS MEASUREMENT IN RELATION TO HOURS OF OPERATION

Early detection of furnace tube erosion and the remedial measures adopted have been discussed in detail in Part 3.1. One result of detecting erosion during initial operation of FBB-1 was the institution of a rigorous program to keep track of metal wastage by means of periodic tube thickness measurement.

Since it is not normal practice to measure tube thickness prior to commissioning boilers, there is no record of the original tube thickness in FBB-1. However, when erosion of tube material became evident in FBB-1, it was decided to record the original tube thickness in FBB-2, in those areas where erosion had been experienced in FBB-1, prior to commencing operation of the boiler. Thus, original tube thickness measurements of FBB-2/A and B were recorded on 1 March 1983.

Following this, tube thickness was measured frequently and, in particular, whenever modifications were made such as application of refractory, installation of sheds and welding of studs.

Table 3-1 contains a chronology of tube thickness and stud length measurements, and records the hours of operation at the time that measurements were taken in any bed.

Table 3-2 contains a record of the monthly operating hours of each bed from initial operation in December 1982, through each heating season, until the end of the last heating season in June 1986.

322 METHODOLOGY AND THE PROBLEM OF CONSISTENT AND COMPARABLE MEASUREMENT

322.1 Methodology

In-situ ultrasonic tube thickness measurements were carried out with the following instruments:

- The very first ultrasonic measurements, on 28 February 1983 and 1 March 1983, were taken using a Marenco Engineering Company's Tokyo Keiki UTM-100 meter which has a flat plate built into the block for calibration of the instrument.

- All subsequent ultrasonic measurements by Foster Wheeler Limited (FWL) and those taken jointly with Public Works Canada (PWC) used a Krautkramer-Branson D.M.1 meter Model #110470, which has a 0.25 in. flat plate pre-set in the equipment for calibration purposes, and is equipped with a 1/2 in. diameter probe. As an additional precaution FWL/PWC also checked the calibration on a 1-1/2 in. long piece of 1-7/8 in. outer diameter boiler tube, which had a wall thickness of 0.140 in.

Measurements taken in 1986, both on in-bed tubes and studs welded on water-wall tubes have been taken with vernier calipers.

322.2 Problem of Consistent and Comparable Measurement

The normal object of periodically measuring tube thickness is to record the rate of wastage and thereby enable calculations to be made predicting the life of boiler pressure parts. Such measurements are also used as a means of developing a good maintenance program, predicting annual boiler availability and, thereby, the economics of boiler operation.

In order to serve these objectives, rates of wastage must be computed with reasonable accuracy, which is only possible if the following conditions are met:

- Locations of low, medium and high wear are clearly identified.
- Repeat measurements are taken exactly, repetitively and accurately relative to base metal, at the identified locations.
- Hours of operation and the loading between readings are factored into the computations (if possible the boiler should be operated steadily at MCR between readings).
- There should be steady, preferably uninterrupted, operation of the boiler between the periodic measurements.
- The gas and particulate flow patterns should not change between readings.
- It should be possible to clean the tube surface to the parent metal without removing metal in the process of cleaning.
- A standardized and proven measurement procedure should be used repetitively.

Unfortunately, in the case of the AFBC boilers at Summerside, most of these conditions simply could not be met. Consequently the readings taken suffer from uncertainties arising from the following factors:

- Due to the application of Lavalox in the initial area of highest erosion, no further reading could be taken in the same locations as the earlier readings.

- The change in turbulence pattern caused by Lavalox application also altered the discernable pattern of erosion, and the tube sections below the Lavalox experienced significant erosion. Therefore subsequent readings were taken in locations between the scalloped bar (see Figure 3-2) and the lower edge of Lavalox refractory.

- Access problems rendered the cleaning of tubes extremely difficult and some of the subsequent readings showed greater than original tube thickness. Hard deposits of compacted ash or slag were often impossible to chip or grind off without damaging, or even removing, the parent metal. Sanding or scraping of hard-caked deposits results in a shiny smooth surface deceptively resembling the parent metal. This makes it difficult to determine whether base metal has or has not been reached.

- The subsequent addition of sheds made access to many of the original measurement points impossible; in addition to which they once again changed the flow patterns in the bed.

- The slope of erosion (i.e. the slope of the eroded surface from the original O.D. of the tube to the deepest section of the pit) in many locations was steep enough or the pitting was such that the probe could not effectively measure the true thickness at that point.

- Other changes made were studding of the waterwall tubes and rodding of in-bed tubes. Both these modifications rendered impossible any access to the original measurement points.

- After the waterwalls were studded, the limited spacing between studs, which was further reduced by the spread of weld metal at stud roots, made it altogether impossible to measure tube wall thickness. Only the stud length above the tube outer diameter could be measured. Every effort was made to clean the tube surface between studs in order to get an accurate measure of the height of the stud above the tube, but there is no certainty this was actually effected in every case. An additional complication resulted from the slight unevenness inherent in the welding of the studs to the tubes. Weld penetration is subject to numerous variables, resulting in differences up to +/-0.030 in. in the height of the welded stud above the tube (see Photograph 34). Consequently no earlier datum now exists, and the stud measurements recorded in the summer of 1986 must themselves form the reference for future readings.

- Furnace inspection in the summer of 1986 revealed that the effect of erosion during the 1985/86 heating season had been confined to rounding the edges at the top outer diameter of each stud. Some studs were worn more than others, and studs located in certain positions had their plateaus worn to form slopes.

  Caliper measurement of studs was in all cases taken so as to measure the highest point of the stud with respect to the surface of the tube. In the majority of cases this method of measurement constituted not a measure of metal wastage but the establishment of a reference or bench mark. Not until the topmost point of the original studs erodes will it be possible to obtain a reasonable measure of the wastage taking place on studded water-walls.

- One element of methodology has suffered from the fact that different people and agencies were involved in the measurement. This element is the reference for locating the points at which thickness was measured. Some measurements were taken using the

> scalloped bar, which is about 2 in. above the upper surface of the distributor plate (see Figure 3-2), and some measurements are referred to the upper surface of the distributor plate. Some measurements locate the measured point with reference to the upper or lower edge of the Lavalox refractory which was trowelled on to protect the tubes from erosion, and sometimes the measured points are said to be located "midway between the edge of the refractory and the surface of the distributor plate". The problem with locating any point with reference to the edge of the refractory is that the edge is uneven, is subject to wear, to bulging, cracking, peeling and spalling.

The overall result of these factors has been that the frequent and assiduous measurement of tube thickness could not serve its normal purpose. From the large number of readings available this report has been able to use only selected sets of readings, which were reasonably comparable with respect to intervening hours of operation. Such readings have been tabulated and contour plots have been prepared in order to visualize the erosion patterns caused by bed turbulence.

3.3 TABLES OF TUBE THICKNESS AND STUD LENGTH MEASUREMENT AND CONTOUR PLOTS

Figure 3-1 shows outline furnace plans of FBB-1 and FBB-2 in relation to the control room, and indicates the nomenclatures and numbering systems used for tube identification. All measurement points on water-walls are based on their heights above the upper surface of the scalloped bar shown in Figure 3-2.

For reasons described in Part 322 the tables and contour plots presented here are restricted to those which show consistent identification of measuring point locations after specified numbers of hours of FBB operation, so that patterns of erosion after one or more heating seasons become evident from the information presented.

Tables of stud length measurement taken in the summer of 1986 are also presented here in order to form a basis for subsequent contour plotting following from another set of readings which will be taken at the same locations in the summer of 1987. Contour plotting of these readings has not been done at this time, because unless at least two sets of readings are contour plotted on the same equipment and even by the same operator they will not meaningfully compare with each other.

The graphics system used for contour plotting is Intergraph. It is run on a Digital PDP 11/70 computer using IGDS software Version 8.5. To process the given data, Monenco's Digital Terrain Modelling software has been used. This software requires an input of random XYZ coordinate points based on a specified grid interval which, in this case, is the actual tube spacing. This new data is then used to generate and load contours into a graphics file along with the associated numerical data. A contour interval is specified which, in this case, is .005 in. The file is then run to produce the contour plots.

The Tables and Contour Plots which follow this page are as follows:

- Tables 3-1 to 3-51 : Pages 3-34 to 3-85
- Contour Plots : Pages 3-86 to 3-100

TABLE 3-1

CHRONOLOGY OF TUBE THICKNESS AND STUD LENGTH MEASUREMENTS

DATE OF MEASUREMENT	MEASURING AGENCY (1)	BEDS MEASURED AND THE HOURS OPERATED UP TO THE DATE OF MEASUREMENT			
		FBB-1		FBB-2	
		A	B	A	B
83/02/28	FWL	539	*	*	*
83/03/01	FWL	*	*	Nil Hours (2)	Nil Hours (2)
83/03/28	FWL	*	*	412	*
83/10/17-18	PWC	619	43	997	Nil Hours (2)
84/01/10	FWL	*	*	1986	484
84/05/28-30	PWC	3072	1700	2774	1053
84/07/11	FWL	3072	*	*	*
84/07/18	FWL	3072	1700	3209	1402
85/02/14	FWL	*	*	5303	*
85/06/06	FWL/PWC	5678	3771	5631	3222
86/05/27	EMR(3)	*	*	9800	5763
86/06/25	EMR(3)	7818	*	*	*

Notes:

(1) FWL = Foster Wheeler Limited; PWC = Public Works Canada; EMR = Energy Mines and Resources Canada.

(2) Measurements taken prior to operation of the bed.

(3) Stud length measurements.

* No measurements taken.

TABLE 3-2

RECORD OF MONTHLY, SEASONAL AND CUMULATIVE OPERATING HOURS FOR FBB-1 AND FBB-2

YR/MTH AND SUBTOTALS	FBB-1				FBB-2			
	BED A		BED B		BED A		BED B	
	HOURS IN THE MONTH	CUMULATIVE HOURS	HOURS IN THE MONTH	CUMULATIVE HOURS	HOURS IN THE MONTH	CUMULATIVE HOURS	HOURS IN THE MONTH	CUMULATIVE HOURS
1982/DEC	80	80	0	0	0	0	0	0
1983/JAN	289	369	43	43	0	0	0	0
/FEB	170	539	0	43	0	0	0	0
/MAR	0	539	0	43	412	412	0	0
/APR	63	602	0	43	0	412	0	0
/MAY	17	619	0	43	585	997	192	192
SUBTOTAL 82-83 SEASON	619		43		997		192	
1983/OCT	0	619	0	43	109	1106	0	192
/NOV	386	1005	240	283	676	1782	292	484
/DEC	204	1209	176	459	204	1986	0	484
1984/JAN	80	1289	59	518	0	1986	0	484
/FEB	99	1388	12	530	197	2183	143	627
/MAR	604	1992	142	672	339	2522	178	805
/APR	489	2481	458	1130	252	2774	248	1053
/MAY	591	3072	570	1700	0	2774	0	1053
/JUN	0	3072	0	1700	59	2833	0	1053
SUBTOTAL 83-84 SEASON	2453		1657		1836		861	

TABLE 3-2 (Cont'd)

RECORD OF MONTHLY, SEASONAL AND CUMULATIVE OPERATING HOURS FOR FBB-1 AND FBB-2

YR/MTH AND SUBTOTALS	FBB-1				FBB-2			
	BED A		BED B		BED A		BED B	
	HOURS IN THE MONTH	CUMULATIVE HOURS	HOURS IN THE MONTH	CUMULATIVE HOURS	HOURS IN THE MONTH	CUMULATIVE HOURS	HOURS IN THE MONTH	CUMULATIVE HOURS
1984/OCT	0	3072	0	1700	376	3209	349	1402
/NOV	62	3134	11	1711	708	3917	516	1918
/DEC	552	3686	182	1893	566	4483	562	2480
1985/JAN	321	4007	255	2148	567	5050	490	2970
/FEB	465	4472	420	2568	253	5303	252	3222
/MAR	744	5216	744	3312	0	5303	0	3222
/APR	462	5678	459	3771	0	5303	0	3222
/MAY	0	5678	0	3771	328	5631	0	3222
SUBTOTAL 84-85 SEASON	2606		2071		2798		2169	
1985/OCT	0	5678	0	3771	292	5923	33	3255
/NOV	0	5678	0	3771	684	6607	276	3531
/DEC	79	5757	0	3771	744	7351	643	4174
1986/JAN	515	6272	283	4054	551	7902	301	4475
/FEB	307	6579	252	4306	672	8574	366	4841
/MAR	65	6644	23	4329	700	9274	666	5507
/APR	195	6839	0	4329	526	9800	256	5763
/MAY	744	7583	0	4329	0	9800	0	5763
/JUN	235	7818	0	4329	0	9800	0	5763
SUBTOTAL 85-86 SEASON	2140		558		4169		2541	

TABLE 3-3
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-1/A WALL/IN-BED: Drum Wall DATE MEASURED: 83-02-28
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes. HOURS OF OPERATION: 539

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.155			.155			.155			.150		.150	.150	.150	.155	.160	.160	.155	.160
2																			
3	.155			.155			.155			.155		.155	.155	.155	.165	.165	.165	.155	.160
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11	.155			.150			.155			.145		.145	.150	.155	.155	.165	.165	.165	.160
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19	.160			.160			.155			.155		.155	.155	.155	.170	.165	.175	.165	.160
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27	.165			.155			.165			.165		.155	.155	.165	.165	.165	.165	.155	.155
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	.155			.155			.155			.155		.155	.155	.165	.165	.165	.165	.165	.165
36																			
37	.165			.155			.155			.165		.155	.165	.170	.165	.165	.165	.165	.155

TABLE 3-4
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-1/A

WALL/IN-BED: Drum Wall

DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.

DATE MEASURED: 84-07-11
HOURS OF OPERATION: 3072

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	21	22	23	24	30	36	48	54	60	72	84
1																			
2	.165	.160	.160	.155	.150	.150	.135	.135	.160	.160									
3																			
4	.165	N/R	.155	.155	.140	.135	.125	.125	N/R	N/R	N/R								
5																			
6							.120	.095		.105	.130								
7																			
8	.160	.155	.145	.155	.140	.135	.110	.090	.140	.150									
9																			
10	.160	.160	.155	.140	.135	.130	.115	.130		.150									
11																			
12	.155	.150	.145	.140	.130	.130	.110	.095	.125	.150									
13																			
14	.150	.150	.145	.140	.135	.130	.120	.095	.100	.120									
15																			
16	.155	.155	.155	.145	.140	.130	.110	.140		.125									
17	.160	.155	.145	.145	.135	.115	.100	.110											
18																			
19	.160	.160	.155	.150	.145	.130	.135	.105	.165	.180									
20																			
21	.160	.155	.160	.145	.145	.135	.125	.105		.180									
22																			
23	.160	.155	.150	.150	.140	.130	.120	.135		.130									
24																			
25																			
26																			
27	.160	.160	.150	.145	.140	.125	.115	.115		.150									
28																			
29	.160	.155	.150	.150	.140	.130	.120	.115		.120									
30																			
31	.155	.185	.150	.140	.130	.120	.110	.135		.120	.145								
32							.110	.100		.120									
33							.125	.105		.115									
34																			
35	.160	.155	.155	.150	.140	.125	.160	.115		.125									
36																			
37	.155	.155	.155	.160	.155	.140	.135	.195											

TABLE 3-5
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-1/A
WALL/IN-BED: Drum Wall
DATE MEASURED: 85-06-06
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 5678

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	21	22	23	24	30	36	48	54	60	72	84
1																			
2																			
3	.165	.165	.160	.150		.135	.130			.120									
4																			
5																			
6																			
7	.160	.160	.150		.140	.115	.090			.150									
8																			
9																			
10																			
11	.160	.150	.150	.140		.115	.095		.115										
12																			
13																			
14																			
15	.165	.160	.155		.140	.125	.110		.120										
16																			
17																			
18																			
19	.165	.160	.155		.145	.130	.100		.155										
20																			
21																			
22																			
23	.160	.155	.155		.140	.125		.100		.130									
24																			
25																			
26																			
27	.155	.150	.150		.135	.120	.120			.155									
28																			
29																			
30																			
31	.155	.215	.195		.130	.120		N/R		.110									
32																			
33																			
34																			
35	.155	.155	.145		.135	.120	.105			.120									
36																			
37																			

TABLE 3-6
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-1/A
WALL/IN-BED: Partition Wall
DATE MEASURED: 83-02-28
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 539

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.150			.145			.145			.140		.135	.135	.140	.145	.140	.145	.155	.155
2																			
3	.155			.140			.140			.140		.140	.140	.140	.145	.145	.145	.155	.160
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11	.150			.140			.140			.135		.130	.140	.145	.155	.150	.155	.155	.155
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19	.165			.160			.165			.165		.165	.145	.150	.155	.160	.155	.165	.155
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27	.160			.165			.165			.160		.155	.165	.165	.155	.160	.155	.160	
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	.155			.165			.160			.155		.155	.160	.160	.165	.165	.165	.165	
36																			
37	.155			.155			.160			.165		.155	.155	.155	.165	.160	.165	.165	.155

TABLE 3-7
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-1/A
WALL/IN-BED: Partition Wall
DATE MEASURED: 84-07-18
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 3072

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	21	22	23	24	30	36	48	54	60	72	84
1	.165	.165	.165	.165	.160	.145	.135	.140		.150									
2																			
3	N/R	.155	.155	.150	.135	.125	.115	.120		.140									
4																			
5	.160	.160	.155	.150	.145	.125	.120	.125		.155									
6																			
7	N/R	N/R	N/R	.155	.150	.140	.120	.135		.150									
8																			
9	N/R	N/R	.180	.145	.140	.135	.125	.130		N/R									
10																			
11	N/R	N/R	N/R	.185	.130	.130	.125	.130	.135	N/R									
12																			
13	.160	.155	.150	.145	.140	.130	.120	.130		.140									
14																			
15	.165	.160	.155	.145	.145	.135	.130	.140		.150									
16																			
17	.155	.155	.145	.140	.140	.135	.135	.140		N/R									
18																			
19	.160	N/R	.160	.155	.150	.150	.135	.140		.160									
20																			
21	.160	.150	.150	.145	.145	N/R	.150	.140		.160									
22																			
23	N/R	N/R	.150	.150	.145	.150	.150	.150											
24																			
25	.165	.155	.155	.160	.160	.170	.160	.165		.165									
26																			
27	.165	.160	.160	.155	.155	.160	.150	.155		.165									
28																			
29	.170	.160	.155	.155	.155	.155	.155	.160											
30																			
31	.165	.160	.185	.155	.155	.155	.155	.160		.170									
32																			
33	.155	.155	.155	N/R	.140	.155	.150	.150		.160									
34																			
35	.165	.160	.160	.160	.160	.160	.160	.160		.165									
36																			
37	.165	.165	.165	.165	.170	.165	.155	.160	.165										

TABLE 3-8
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-1/A
WALL/IN-BED: Partition Wall
DATE MEASURED: 85-06-06
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 5678

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	21	22	23	24	30	36	48	54	60	72	84
1																			
2																			
3	.160	.160	N/R		.145	.130	.120		.135										
4																			
5																			
6																			
7	.165	N/R	.165	N/R		.140	.125		.145										
8																			
9																			
10																			
11	.160	.155	.150	.140		.135	.130		N/R										
12																			
13																			
14																			
15	.165	.160	.160	.150		.135	.130		.145										
16																			
17																			
18																			
19	.160	.155	.160	.160		.145	.145		.155										
20																			
21																			
22																			
23	N/R	.155	.150		.150	N/R	.150		.155										
24																			
25																			
26																			
27	.160	.160	.155	.150		.155	.150		.160										
28																			
29																			
30																			
31	N/R	.160	.150	.160		.165	.155												
32																			
33																			
34																			
35	.165	.160	.160	.160		.160	.160		.160										
36																			
37																			

TABLE 3-9
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-1/B
WALL/IN-BED: Front Wall
DATE MEASURED: 84-07-18
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 1700

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	28	30	36	48	54	60	72	84
1																			
2																			
3	.165	.165	.160	.160	.160	.165	.160	.165	.165										
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11	.160	.160	.160	.160	.160	.160	.160	.160	.165										
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19	.160	.160	.155	.155	.155	.155	.155	.155	.155										
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27	.160	.160	.160	.160	.160	.155	.155	.160	.160										
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	.160	.160	.160	.155	.160	.160	.160	.160	.155										
36																			
37																			

TABLE 3-10
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-1/B
WALL/IN-BED: Front Wall
DATE MEASURED: 85-06-06
HOURS OF OPERATION: 3771
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.

TUBE #	Height of Measured Point Above Scallop Bar in Inches																	
	6	8	10	12	14	16	18	20	21	22	23	24	30	36	48	54	60	72	84
1																			
2																			
3	.165	.165	.165	.165	.165	.165	.170	.170	.170										
4																			
5																			
6																			
7	.170	.170	.170	.170	.170	.170	.170	.170	.170										
8																			
9																			
10																			
11	.165	.165	.165	.165	.165	.165	.165	.165	.165										
12																			
13																			
14																			
15	.170	.170	.170	.170	.170	.170	.170	.170	.170										
16																			
17																			
18																			
19	.165	.165	.160	.160	.160	.160	.160	.160	.165										
20																			
21																			
22																			
23	.175	.175	.170	.170	.170	.170	.170	.170	.170										
24																			
25																			
26																			
27	.170	.165	.165	.165	.165	.165	.165	.170	.170										
28																			
29																			
30																			
31	N/R	N/R	N/R	.170	.170	.170	.170	.170	.170	.175									
32																			
33																			
34																			
35	.170	.170	.165	.165	.160	.165	.160	.165	.165										
36																			
37																			

TABLE 3-11
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-1/B
WALL/IN-BED: Partition Wall
DATE MEASURED: 84-07-18
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 1700

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	21	22	23	24	30	36	48	54	60	72	84
1																			
2																			
3	.160	.160	.150	.155	.150	.145	.140	.135		.150									
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11	.160	.160	.155	.150	.140	.135	.125	.130	.135	.145	.150								
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19	.155	.155	.150	.145	.135	.120	.120	.135		.150									
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27								.160		.160									
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	.160		.160	.155	.150	.150	.155	.155		.160									
36																			
37																			

TABLE 3-12
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-1/B
WALL/IN-BED: Partition Wall
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
DATE MEASURED: 85-06-06
HOURS OF OPERATION: 3771

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	21	22	23	24	30	36	48	54	60	72	84
1																			
2																			
3	.165	.160	.160	.155	.155	.145		.140		.160									
4																			
5																			
6																			
7	.170	.165	.160		.155	.150		.150		.160									
8																			
9																			
10																			
11	.165	.165	.160	.155		.145	.130	.130		.160									
12																			
13																			
14																			
15	.165	.160	.155	.145		.130	.120			.160									
16																			
17																			
18																			
19	.160	.160	.155	.155		.130	.130			.160									
20																			
21																			
22																			
23			.155	.155		.155		.160		.165									
24																			
25																			
26																			
27										.165									
28																			
29																			
30																			
31			.160	.160	.160	.160			.165										
32																			
33																			
34																			
35				.155		.160	.155	.160		.165									
36																			
37																			

TABLE 3-13
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-1/B

WALL/IN-BED: In-Bed Tubes

DATE MEASURED: 84-07-18

DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.

HOURS OF OPERATION: 1700

TUBE #	Distance From Inside of Bend on Sloping Section																		
	6	8	10	12	14	16	18	20	22	24	26	28	32	36	48	54	60	72	84
1																			
2																			
3		.280		.275		.290		.285		.280		.290							
4																			
5		.295		.290		.295		.285		.290		.295							
6																			
7		.275		.255		.280		.280		.290		.295							
8																			
9		.285		.280		.290		.285		.290		.295	.295						
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35																			
36																			
37																			

TABLE 3-14
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-1/B
WALL/IN-BED: In-Bed Tubes
DATE MEASURED: 85-06-06
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 3771

TUBE #	Distance From Inside of Bend on Sloping Section																		
	6	8	10	12	14	16	18	20	22	24	26	28	32	36	48	54	60	72	84
1																			
2																			
3		.220		.135		.145		.130		.130		.120	.150						
4																			
5		.255		.230		.220		.195		.195		.950	.170						
6																			
7		.240		.190		.190		.195		.190		.200	.195						
8																			
9		.235		.205		.195		.195		.215		.230	.230						
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35																			
36																			
37																			

TABLE 3-15
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A WALL/IN-BED: Drum Wall DATE MEASURED: 83-03-01
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes. HOURS OF OPERATION: NIL

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.170			.170			.170			.170		.165	.170	.170	.170	.165	.170	.165	.165
2																			
3	.170			.170			.170			.170		.170	.170	.170	.170	.170	.170	.170	.170
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11	.170			.170			.170			.165		.170	.165	.165	.170	.170	.165	.170	.165
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19	.170			.165			.170			.165		.170	.170	.170	.170	.170	.170	.170	.170
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27	.170			.170			.170			.170		.170	.170	.170	.170	.170	.170	.170	.170
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	.165			.160			.165			.165		.165	.165	.165	.165	.160	.165	.165	.165
36																			
37	.165			.165			.170			.165		.170	.170	.170	.170	.170	.165	.165	.170

TABLE 3-16
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A
WALL/IN-BED: Drum Wall
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
DATE MEASURED: 84-07-18
HOURS OF OPERATION: 3209

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	28	30	36	48	54	60	72	84
1																			
2																			
3	.165	.155	.145	.145	.135	.125	.120	.130	.150										
4																			
5																			
6																			
7	.160	.150.	.140	.135	.130	.120	.110	.115	.135										
8																			
9																			
10																			
11	.165	.155	.145	.135	.125	.120	.105	.115	.145										
12																			
13																			
14																			
15	.165	.155	.145	.135	.130	.125	.115	.115	.145										
16																			
17																			
18																			
19	.160	.160	.150	.140	.130	.125	.120	.120	.145										
20																			
21																			
22																			
23	.165	.160	.150	.150	.150	.150	.135	.135	.155										
24																			
25																			
26																			
27	.165	.165	.155	.155	.155	.145	.130	.130	.150										
28																			
29																			
30																			
31	.160	.155	.150	.145	.145	.140	.135	.135	.150										
32																			
33																			
34																			
35	.155	.150	.150	.150	.145	.145	.140	.145	.150										
36																			
37																			

TABLE 3-17
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A WALL/IN-BED: Drum Wall DATE MEASURED: 85-06-06
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes. HOURS OF OPERATION: 5631

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	21	22	23	24	30	36	48	54	60	72	84
1																			
2																			
3	N/R	.155	.150	.140	.125		.120	.120	.125										
4																			
5																			
6																			
7	.160	.150	.145	.140		.110	.110	.095	.145										
8																			
9																			
10																			
11	N/R	.155	.150	.135	.120	.125	.135	.130											
12																			
13																			
14																			
15	N/R	.160	.150	.130		.115	.135		.135										
16																			
17																			
18																			
19	.155	.155	.145		.135	.125	.110		.135										
20																			
21																			
22																			
23	.160	.145	.140	.140		.140	.130		.150										
24																			
25																			
26																			
27	.155	.155	.150		.145	.145	.125		.145										
28																			
29																			
30																			
31	.155	.155	.150		.140	.135	.125		.135										
32																			
33																			
34																			
35	.145	.140	.145		.145	.135	.135			.145									
36																			
37																			

TABLE 3-18
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A WALL/IN-BED: Partition Wall
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
DATE MEASURED: 83-03-01
HOURS OF OPERATION: NIL

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.170			.170			.165			.165		.160	.165	.165	.165	.165	.165	.165	.170
2																			
3	.170			.165			.170			.165		.165	.165	.165	.165	.165	.165	.165	.165
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11	.170			.170			.170			.170		.170	.165	.170	.170	.175	.170	.170	.175
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19	.175			.175			.170			.170		.170	.175	.170	.170	.170	.175	.170	.170
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27	.170			.160			.160			.165		.165	.165	.165	.170	.170	.170	.165	.170
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	.170			.170			.170			.170		.170	.170	.170	.170	.170	.170	.170	.170
36																			
37	.170			.165			.160			.165		1.70	.165	.165	.165	.170	.160	.170	.170

TABLE 3-19
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A
WALL/IN-BED: Partition Wall
DATE MEASURED: 84-07-18
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 3209

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	28	30	36	48	54	60	72	84
1																			
2																			
3	.165	.155	.140	.135	.130	.130	.125	.140											
4																			
5																			
6																			
7	.155	.160	.150	.140	.130	.120	.110	.140											
8																			
9																			
10																			
11	.150	.140	.130	.130	.130	.120	.115	.130	.155										
12																			
13																			
14																			
15	.160	.145	.130	.125	.125	.120	.120	.125	.155										
16																			
17																			
18																			
19	.160	.155	.155	.150	.150	.145	.130	.135	.160										
20																			
21																			
22																			
23	.165	.160	.155	.155	.160	.155	.160	.160	.165										
24																			
25																			
26																			
27	.155	.140	.140	.140	.145	.155	.150	.160											
28																			
29																			
30																			
31	.155	.150	.145	.145	.145	.150	.145	.150	.150										
32																			
33																			
34																			
35	.160	.155	.150	.155	.155	.155	.160	.160	.160										
36																			
37																			

TABLE 3-20
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A
WALL/IN-BED: Partition Wall
DATE MEASURED: 85-06-06
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 5631

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	21	22	23	24	30	36	48	54	60	72	84
1																			
2																			
3	.160	.150	.150	.135	.130	.125	.120												
4																			
5																			
6																			
7	.160	.155		.145	.135	.115	.260		.125										
8																			
9																			
10																			
11	.160	.145	.145	.130		.120	.120		.140										
12																			
13																			
14																			
15	.150	.135	.135		.130	.120	.120			.145									
16																			
17																			
18																			
19	.165	.165	.160		.165	.150		.140	.160										
20																			
21																			
22																			
23	.170	.160	.160		.160	.165	.170			.165									
24																			
25																			
26																			
27	.160	.150	.140	.155	.150	.160	.160			.170									
28																			
29																			
30																			
31	.160	.155	.155	.145	.145	.155	.150												
32																			
33																			
34																			
35	.160	.155	.155	.155		.160	.170		.165										
36																			
37																			

TABLE 3-21
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A
WALL/IN-BED: Stoker Wall
DATE MEASURED: 83-03-01
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: NIL

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.175			.170			.175			.170		.170	.180	.180					
2																			
3	.170			.170			.170			.170		.170	.170	.175					
4																			
5																			
6																			
7																			
8	.165			.165			.170			.170		.165	.165	.165					
9																			
10																			
11																			
12																			
13																			
14	.170			.170			.165			.165		.170	.165	.170	.170				
15																			
16	.165			.165			.170			.165		.170	.170	.165	.170				
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35																			
36																			
37																			

TABLE 3-22
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A
WALL/IN-BED: Stoker Wall
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
DATE MEASURED: 84-01-10
HOURS OF OPERATION: 1986

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	21	22	24	26	28	30	36	49	54	60	72	84
1	.170			.185			.175	.230											
2															.185	.180	.165	.165	.175
3	.170			.175			.170	.160											
4															N/R	N/R	N/R	N/R	N/R
5																			
6																			
7																			
8	.160			.180			.185	N/R											
9															N/R	N/R	N/R	N/R	N/R
10																			
11																			
12																			
13																			
14	.170			N/R			N/R	N/R											
15															N/R	N/R	N/R	N/R	N/R
16	.165			N/R			N/R	N/R											
17															N/R	N/R	N/R	N/R	N/R
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35																			
36																			
37																			

TABLE 3-23
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A
WALL/IN-BED: Sorbent Injection Wall
DATE MEASURED: 83-03-01
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: NIL

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.170			.165			.165			.165		.165	.170	.170	.170	.170	.170	.165	.165
2																			
3	.170			.165			.165								.160	.165	.165	.170	.170
4																			
5																			
6																			
7																			
8	.170			.170			.170			.165		.165	.165	.165	.170	.165	.165	.160	
9																			
10																			
11																			
12																			
13																			
14	.175			.175			.175			.175		.175	.175	.165			.170	.170	.175
15																			
16	.175			.170			.170			.170		.175	.170	.170	.170	.170	.165	.170	.170
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35																			
36																			
37																			

TABLE 3-24
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A
WALL/IN-BED: Sorbent Injection Wall
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
DATE MEASURED: 85-02-14
HOURS OF OPERATION: 5303

TUBE #	Height of Measured Point Above Scallop Bar in Inches																	
	6	10	12	13	14	16	18	19	20	21	22	23	30	36	48	54	60	72	84
1	.175		.170		COULD NOT CLEAN TUBE					.155									
2		.160		.150		.140	.125			.115	.130								
3	.175		.155			N/R	.120	.120	.105	.090	N/R								
4						N/R	N/R	N/R	N/R	N/R									
5		.160		.145															
6		.160				.205		.135			.100								
7		.160			.145	.150		.135			.105	.095							
8	.175	.160	.155	.140	.180	.140		.135		.155									
9		.160		.150		.135		.130		.150									
10		.155		.150		.140		.135		.150									
11		.160		.150		.140		.135		.150									
12		.160		.140		.140		.130		.145									
13		.160		.150		.140		.135			.155								
14	.175	.165	.165	.155		.150		.140			.160								
15		.170		.160		.150		.140			.165								
16	.175		.175					.155		.175									
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35																			
36																			
37																			

TABLE 3-25
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/B
WALL/IN-BED: Front Wall
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
DATE MEASURED: 83-03-01
HOURS OF OPERATION: NIL

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.170			.155			.155			.160		.155	.155	.155	.155	.155	.155	.155	.155
2																			
3	.170			.170			.160			.160		.165	.160	.160	.155	.165	.160	.160	.155
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11	.165			.165			.165			.160		.160	.160	.160	.160	.160	.160	.155	.160
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20	.175			.165			.170			.170		.155	.160	.160	.160	.160	.160	.160	
21																			
22																			
23																			
24																			
25																			
26																			
27	.160			.165			.170			.165		.160	.155	.165	.160	.160	.160	.160	.160
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	.170			.165			.170			.160		.160	.165	.160	.155	.160	.160	.155	.160
36																			
37	.160			.165			.170			.175		.175	.165	.165	.160	.160	.160	.195	.165

TABLE 3-26
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/B
WALL/IN-BED: Front Wall
DATE MEASURED: 84-07-18
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 1402

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	21	22	23	24	30	36	48	54	60	72	84
1																			
2																			
3	.165	.165	.160	.165	.160	.165	.160	.165											
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11	.165	.165	.165	.165	.165	.160	.160	.165		.165									
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19	.165	.160	.160	.165	.165	.165	.165	.160											
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27	.165	.165	.165	.165	.165	.165	.165	.165											
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	.160	.165	.165	.165	.165	.160	.165	.165											
36																			
37																			

TABLE 3-27
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/B
WALL/IN-BED: Front Wall
DATE MEASURED: 85-06-06
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 3222

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	21	22	23	24	30	36	48	54	60	72	84
1																			
2																			
3	.170	.170	.165	.170	.165	.160	.160	.165											
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11	.170	.165	.170	.170	.170	.165	.165	.165		.165									
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19	.170	.170	.165	.170	.165	.165	.165	.165											
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27	.170	.170	.170	.170	.170	.165	.165	.170											
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	N/R	.170	.165	.170	.170	.165	.165	.170											
36																			
37																			

TABLE 3-28
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/B

WALL/IN-BED: Partition Wall

DATE MEASURED: 83-03-01

DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.

HOURS OF OPERATION: NIL

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.170			.165			.165			.165		.165	.165	.170	.165	.170	.165	.170	.170
2																			
3	.170			.170			.170			.170		.170	.165	.165	.170	.170	.155	.155	.170
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11	.165			.165			.165			.170		.165	.175	.165	.170	.175	.165	.155	.165
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20	.175			.170			.170			.165		.170	.165	.165	.170	.175	.170	.170	.165
21																			
22																			
23																			
24																			
25																			
26																			
27										.160		.160	.155	.155	.165	.155	.155	.155	.160
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	.165			.155			.160			.160		.155	.155	.165	.160	.165	.170	.165	.165
36																			
37	.160			.165			.155			.160		.155	.160	.160	.155	.155	.165	.165	.165

TABLE 3-29
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/B
WALL/IN-BED: Partition Wall
DATE MEASURED: 84-07-18
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 1402

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	21	22	23	24	30	36	48	54	60	72	84
1																			
2																			
3	.160	.160	.155	.155	.150	.150	.145	.150		.160									
4																			
5																			
6																			
7	.160	.160	.155	.150	.150	.145	.140	.150		.160									
8																			
9																			
10																			
11	.165	.160	.155	.155	.150	.150	.155	.160		.165									
12																			
13																			
14																			
15	.160	.155	.150	.150	.150	.145	.145	.155		.160									
16																			
17																			
18																			
19	.165	.160	.160	.155	.155	.155	.155	.160		.165									
20																			
21																			
22																			
23	.165	.165	.160	.160	.160	.165	.160	.160		.165									
24																			
25																			
26																			
27									.160										
28																			
29																			
30																			
31									.165										
32																			
33																			
34																			
35	.160		.160	.155	.155	.155	.155	.160		N/R									
36																			
37																			

TABLE 3-30
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/B
WALL/IN-BED: Partition Wall
DATE MEASURED: 85-06-06
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 3222

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	21	22	23	24	30	36	48	54	60	72	84
1																			
2																			
3	.165	.165	.160		.155	.150	.520		.160										
4																			
5																			
6																			
7	.165	.165	.160	.155		.150	.145		.160										
8																			
9																			
10																			
11	.165	.165	.165	.160		.150	.180		.165										
12																			
13																			
14																			
15	.165	.160	.155	.155		.150	N/R		N/R										
16																			
17																			
18																			
19	.170	.165	.165	.160		.160	.160		N/R										
20																			
21																			
22																			
23		.165		.160		.160	.160		.165										
24																			
25																			
26																			
27									.165										
28																			
29																			
30																			
31	.165			.160	.160	.160	.160												
32																			
33																			
34																			
35				.160		.155	.155		.165										
36																			
37																			

TABLE 3-31
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/B WALL/IN-BED: Sorbent Injection Wall DATE MEASURED: 83-03-01

DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes. HOURS OF OPERATION: NIL

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17	.170			.170			.170			.170		.165	.170	.170	.170	.170	.170	.170	.170
18																			
19	.170			.170			.170			.170		.170	.170	.165			.170	.170	.170
20																			
21																			
22																			
23																			
24																			
25	.170			.170			.165			.170		.170	.170	.170	.165	.170	.165	.160	
26																			
27																			
28																			
29																			
30																			
31																			
32	.165			.170			.170			.170		.170	.170	.170	.165	.170	.175	.165	.170
33																			
34	.170			.170			.170			.170		.160	.170	.165	.165	1.70	.170	.165	.165
35																			
36																			
37																			

TABLE 3-32
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/B
WALL/IN-BED: Sorbent Injection Wall
DATE MEASURED: 84-01-10
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 484

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17	.180			.170			.170			.180		.180							
18																			
19	.180			.170			.160			.190		.190							
20																			
21																			
22																			
23																			
24																			
25	.170			.165			.155			.180		.180							
26																			
27																			
28																			
29																			
30																			
31																			
32	.170			.170			.165			.200		.215							
33																			
34	.170			.180			.180			.190		.185							
35																			
36																			
37																			

TABLE 3-33
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/B
WALL/IN-BED: Stoker Wall
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
DATE MEASURED: 83-03-01
HOURS OF OPERATION: NIL

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17							.150			.160		.155	.155	.155	.155	.160	.160	.155	.160
18																			
19	.145			.150			.155			.165		.160	.160	.160	.160				
20																			
21																			
22																			
23																			
24																			
25	.155			.155			.160			.160		.160	.155	.155	.160				
26																			
27																			
28																			
29																			
30																			
31																			
32	.155			.165			.155			.165		.155	.165	.155	.160				
33																			
34	.165			.160			.160			.170				.160					
35																			
36																			
37																			

TABLE 3-34
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/B
WALL/IN-BED: Stoker Wall
DATE MEASURED: 84-01-10
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 484

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17	.180			.180			.165			.175		.190							
18																			
19	.175			.160			.165			.175		.180							
20																			
21																			
22																			
23																			
24																			
25	.170			.170			.175			.170		.190							
26																			
27																			
28																			
29																			
30																			
31																			
32	.170			.170			.195			.190		.180							
33																			
34	.170			.170			.180			.210		.180							
35																			
36																			
37																			

TABLE 3-35
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A   WALL/IN-BED: Drum Wall   DATE MEASURED: 83-03-28
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.   HOURS OF OPERATION: 412

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.170			.165			.155			.155		.155	.160	.165	.170	.165	.170	.170	.170
2																			
3	.170			.160			.155			.160		.165	.165	.170	.165	.170	.170	.170	.170
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11	.165			.165			.155			.155		.155	.155	.165	.165	.165	.165	.170	.170
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19	.165			.165			.155			.155		.160	.165	.165	.165	.165	.165	.170	.175
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27	.170			.165			.160			.155		.160	.165	.170	.170	.170	.170	.170	.175
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	.160			.155			.155			.155		.160	.160	.160	.165	.160	.160	.165	.165
36																			
37	.170			.160			.155			.155		.160	.160	.160	.165	.165	.165	.170	.165

TABLE 3-36
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A
WALL/IN-BED: Stoker Wall
DATE MEASURED: 33-03-28
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 412

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.165			.160			.155			.145		.155	.155	.155	.165	.160	.160		
2																			
3	.170			.165			.160			.160		.160	.165	.165	.165				
4																			
5																			
6																			
7																			
8	.165			.165			.165			.160		.155	.165	.165	.165				
9																			
10																			
11																			
12																			
13																			
14	.160			.165			.165			.160		.165	.160	.165	.160				
15																			
16	.160			.165			.170			.165		.165	.165	.170	.165				
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35																			
36																			
37																			

TABLE 3-37
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A
WALL/IN-BED: Sorbent Injection Wall
DATE MEASURED: 83-03-28
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 412

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.160			.160			.160			.160		.155	.160	.165	.160	.165	.165	.165	.170
2																			
3	.170			.165			.155								.155	.165	.165	.165	.165
4																			
5																			
6																			
7																			
8	.165			.160			.160			.160		.165	.165	.160	.165	.170	.165	.155	
9																			
10																			
11																			
12																			
13																			
14	.170			.170			.165			.170		.170	.170	.160			.165	.170	.175
15																			
16	.170			.170			.160			.165		.165	.165	.170	.160	.170	.170	.170	.175
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35																			
36																			
37																			

TABLE 3-38
TUBE THICKNESS MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A

WALL/IN-BED: Partition Wall

DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.

DATE MEASURED: 83-03-28

HOURS OF OPERATION: 412

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.165			.155			.155			.155		.165	.160	.165	.170	.165	.165	.165	.165°
2																			
3	.165			.155			.160			.160		.165	.160	.165	.165	.165	.165	.170	.165
4																			
5																			
6																			
7																			
8																			
9																			
10	.170			.160			.165			.165		.165	.165	.165	.165	.170	.170	.170	.170
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19	.170			.170			.170			.170		.175	.170	.170	.170	.170	.170	.170	.170
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27	.160			.170			.160			.170		.170	.165	.170	.170	.170	.170	.170	.170
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	.170			.160			.165			.170		.170	.165	.170	.170	.165	.170	.170	.170
36																			
37	.170			.165			.165			.165		.165	.165	.165	.165	.165	.165	.165	.165

TABLE 3-39
STUD LENGTH MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A
WALL/IN-BED: Drum Wall
DATE MEASURED: 86-05-27
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 9800

TUBE #	Height of Measured Point Above Scallop Bar in Inches																	
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.625			.641			.656			.656		.594	.594	.625	.625	.636			
2																			
3	.688			.688			.563			.625		.594	.594	.625	.625	.688			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11	.641			.625			.625			.625		.594	.594	.594	.594	.656			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19	.688			.656			.563			.594		.656	.625	.625	.625	.656			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27	.625			.656			.625			.625		.688	.688	.625	.625	.625			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	.688			.656			.672			.656		.656	.641	.594	.641	.625			
36																			
37	.641			.688			.594			.594		.625	.641	.641	.594	.609			

TABLE 3-40
STUD LENGTH MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.

WALL/IN-BED: Partition Wall

DATE MEASURED: 86-05-27
HOURS OF OPERATION: 9800

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.625			.656			.656			.594		.594	.563	.688	.594	.641			
2																			
3	.719			.688			.656			.531		.531	.594	.625	.656	.641			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11	.719			.688			.594			.625		.656	.594	.688	.656	.641			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19	.625			.688			.469			.578		.594	.563		.656	.641			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27	.656			.656			.469			.563		.594	.625	.594	.625	.578			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	.688			.656			.469			.5		.609	.594	.625	.609	.563			
36																			
37	.625			.656			.594			.438		.5	.625	.609	.563	.578			

TABLE 3-41
STUD LENGTH MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.

WALL/IN-BED: Stoker Wall

DATE MEASURED: 86-05-27
HOURS OF OPERATION: 9800

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.656			.656			.656			.625		.563	.594	.594	.625	.563			
2																			
3	.656			.656			.625			.563		.594	.594	.594	.594	.563			
4																			
5																			
6																			
7																			
8	.688			.563			.656			.625		.656	.594	.563	REF	REF			
9																			
10																			
11																			
12																			
13																			
14	.656			.656			.656			.594		.563	.594	.594	.656	.609			
15																			
16	.594			.688			.656			.625		.656	.594	.609	.641	.609			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35																			
36																			
37																			

TABLE 3-42
STUD LENGTH MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/A WALL/IN-BED: Sorbent Injection Wall DATE MEASURED: 86-05-27
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes. HOURS OF OPERATION: 9800

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.656			.656			.656			.594		.594	.656	.625	.625	.688			
2																			
3	.625			REF											.688	.625			
4																			
5																			
6																			
7																			
8	.656			REF			.594			.594		.594	.625	.688	.688	.625			
9																			
10																			
11																			
12																			
13																			
14	.594			.656			.656			.656		.594		REF	REF	.656			
15																			
16	.625			.688			.672			.625		.594		.625	REF	.672			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35																			
36																			
37																			

TABLE 3-43
STUD LENGTH MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/B
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.

WALL/IN-BED: Front Wall

DATE MEASURED: 86-05-27
HOURS OF OPERATION: 5763

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	28	30	36	48	54	60	72	84
1																			
2																			
3	.656			.656			.656												
4																			
5																			
6																			
7	.688			.672			.656												
8																			
9																			
10																			
11	.656			.656			.672												
12																			
13																			
14																			
15	.656			.641			.656												
16																			
17																			
18																			
19	.656			.656			.672												
20																			
21																			
22																			
23	.656			.656			.656												
24																			
25																			
26																			
27	.641			.656			.672												
28																			
29																			
30																			
31	.672			.656			.672												
32																			
33																			
34																			
35	.656			.656			.672												
36																			
37	.656			.672			.672												

TABLE 3-44
STUD LENGTH MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/B
WALL/IN-BED: Partition Wall
DATE MEASURED: 86-05-27
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 5763

TUBE	Height of Measured Point Above Scallop Bar in Inches																		
#	6	8	10	12	14	16	18	20	22	24	26	28	30	36	48	54	60	72	84
1	.656			.672															
2																			
3	.656			.656			.656												
4																			
5																			
6																			
7	.656			.656			.641												
8																			
9																			
10																			
11	.656			.672			.672												
12																			
13																			
14																			
15	.672			.656			.656												
16																			
17																			
18	.672			.672			.672												
19	.672			.672			.672												
20																			
21																			
22																			
23	.656			.672			.656												
24																			
25																			
26																			
27	.641			.656			.656												
28																			
29																			
30																			
31	.641			.641			.656												
32																			
33																			
34																			
35	.641			.641			.656												
36																			
37																			

TABLE 3-45
STUD LENGTH MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/B
WALL/IN-BED: Sorbent Injection Wall
DATE MEASURED: 86-05-27
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 5763

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	28	30	36	48	54	60	72	84
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17	.656			.656			.641												
18																			
19	.625			.641			.656												
20																			
21																			
22																			
23																			
24																			
25	.625			.625			.656												
26																			
27																			
28																			
29																			
30																			
31																			
32	.656			.656			.625												
33																			
34	.656			.672			.641												
35																			
36																			
37																			

TABLE 3-46
STUD LENGTH MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/B
WALL/IN-BED: Stoker Wall
DATE MEASURED: 86-05-27
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 5763

TUBE #	Height of Measured Point Above Scallop Bar in Inches																		
	6	8	10	12	14	16	18	20	22	24	26	28	30	36	48	54	60	72	84
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17	.641			.625			.625												
18																			
19	.625			.641			.641												
20																			
21																			
22																			
23																			
24																			
25	.641			.625			.625												
26																			
27																			
28																			
29																			
30																			
31																			
32	.625			.656			.656												
33																			
34	.656			.625			.656												
35																			
36																			
37																			

TABLE 3-47
TUBE DIAMETER MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-2/B
WALL/IN-BED: In-Bed Tubes
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
DATE MEASURED: 86-05-27
HOURS OF OPERATION: 5763

TUBE #	Distance Along Sloping Section From Inside of Bend																		
	6	8	10	12	14	16	18	20	22	24	30	36	42	48	54	60	66	72	78
1																			
2																			
3	2.25			2.25			2.219			2.25	2.25	2.219	2.234	2.25	2.25	2.25	2.266	2.281	2.281
4																			
5																			
6	2.25			2.234			2.25			2.266	2.25	2.234	2.188	2.25	2.25	2.25	2.281	2.281	2.313
7	2.25			2.25			2.25			2.281	2.25	2.234	2.219	2.234	2.25	2.25	2.25	2.297	2.313
8	2.25			2.25			2.25			2.281	2.281	2.188	2.25	2.266	2.25	2.25	2.25	2.281	2.313
9																			
10																			
11																			
12	2.25			2.25			2.25			2.281	2.266	2.25	2.25	2.25	2.25	2.234	2.25	2.281	2.313
13																			
14																			
15																			
16	2.25			2.266			2.25			2.25	2.25	2.203	2.25	2.25	2.25	2.25	2.25	2.281	2.313
17																			
18											2.25	2.25	2.25	2.25	2.25	2.266	2.266	2.281	2.313
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35																			
36																			
37																			

TABLE 3-48
STUD LENGTH MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-1/A   WALL/IN-BED: Drum Wall   DATE MEASURED: 86-06-25
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.   HOURS OF OPERATION: 7818

TUBE	Distance Along Sloping Section From Inside of Bend																		
#	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.641			.641			.641			.625		.594	.625	.625	.625	.625			
2																			
3	.609			.609			.641			.5		.594	.609	.625	.625	.625			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11	.625			.609			.625			.641		.563	.609	.625	.641	.656			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19	.656			.625			.594			.563		.563	.594	.625	.625	.656			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27	.656			.656			.625			.609		.625	.594	.609	.625	.641			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	.625			.625			.594			.578		.594	.625	.625	.609	.625			
36																			
37	.625			.625			.641			.641		.594	.609	.625	.625	.625			

TABLE 3-49
STUD LENGTH MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-1/A WALL/IN-BED: Partition Wall DATE MEASURED: 86-06-25
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes. HOURS OF OPERATION: 7818

TUBE #	Distance Along Sloping Section From Inside of Bend																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.656			.656			.625			.563		.563	.594	.594	.609	.641			
2																			
3	.625			.625			.641			.609		.563	.625	.641	.656	.656			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11	.615			.625			.563			.625		.625	.594	.625	.625	.641			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19	.656			.609			.5			.594		.594	.656	.625	.625	.625			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27	.656			.563			.531			.625		.594	.609	.609	.625	.609			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35	.625			.625			.563			.547		.641	.656	.656	.625	.641			
36																			
37	.656			.625			.594			.563		.563	.641	.641	.625	.641			

TABLE 3-50
STUD LENGTH MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FBB-1/A WALL/IN-BED: Stoker Wall DATE MEASURED: 86-06-25
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes. HOURS OF OPERATION: 7818

TUBE	Distance Along Sloping Section From Inside of Bend																		
#	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.625			.656			.609			.594		.594	.563	.609	.625	.625			
2																			
3	.641			.641			.609			.563		.594	.625	.594	.594				
4																			
5																			
6																			
7																			
8	.625			.656			.563			.531		.625	.625	.625	.609	.625			
9																			
10																			
11																			
12																			
13																			
14	.625			.641			.563			.594		.563	.625	.594	.609	.641			
15																			
16	.625			.625			.625			.563		.656	.594	.625	.609	.625			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35																			
36																			
37																			

TABLE 3-51
STUD LENGTH MEASUREMENTS IN FLUIDIZED BED BOILERS

BOILER/BED: FPB-1/A
WALL/IN-BED: Sorbent Injection Wall
DATE MEASURED: 86-06-25
DRAWING REFERENCE: Figure 3-1 for water-wall tubes; Figure 3-2 for in-bed tubes.
HOURS OF OPERATION: 7818

TUBE #	Distance Along Sloping Section From Inside of Bend																		
	6	8	10	12	14	16	18	20	22	24	26	30	36	42	48	54	60	72	84
1	.656			.656			.656			.516		.594	.594	.625	.641	.625			
2																			
3	.625			.656											.656	.656			
4																			
5																			
6																			
7																			
8	.656			.641			.656			.594		.563	.625	.656	.641	.641			
9																			
10																			
11																			
12																			
13																			
14	.625			.625			.625			.594		.563	.563	.625					
15																			
16	.656			.625			.656			.625		.563	.625	.594	.609	.641			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35																			
36																			
37																			

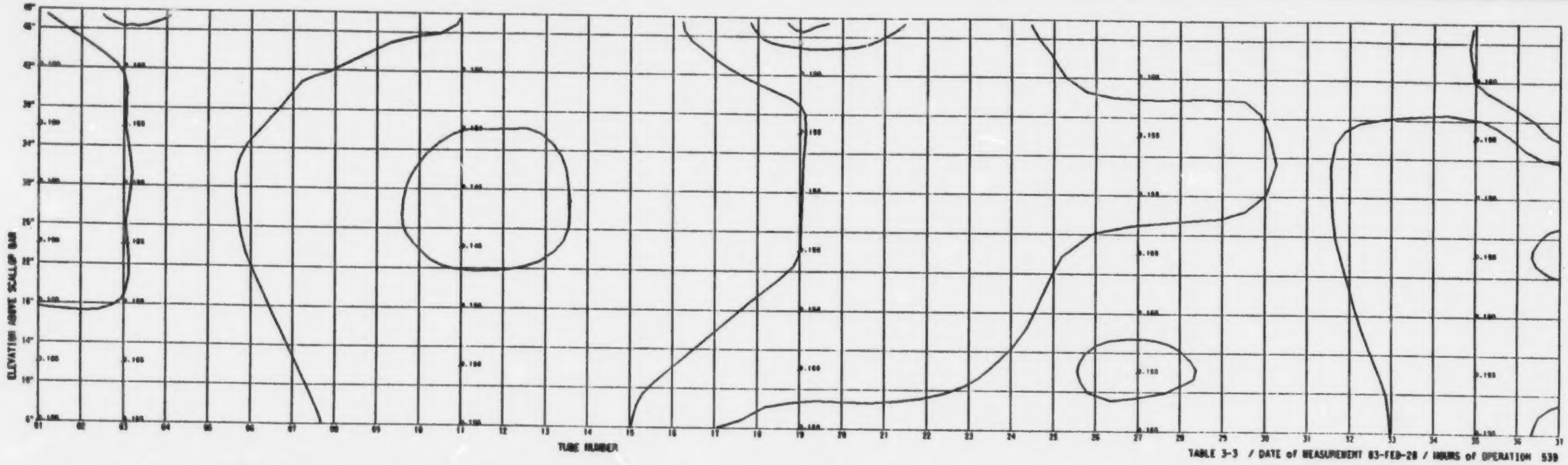


TABLE 3-3 / DATE of MEASUREMENT 83-FEB-28 / HOURS of OPERATION 539

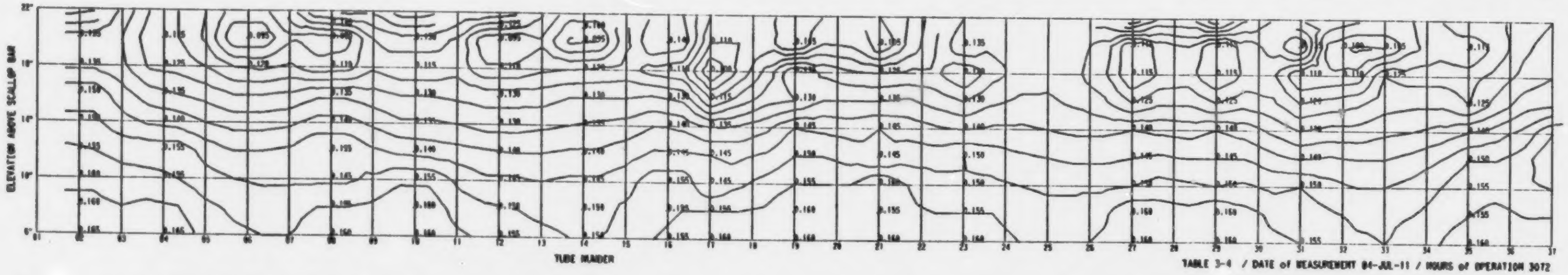


TABLE 3-4 / DATE of MEASUREMENT 84-JUL-11 / HOURS of OPERATION 3072

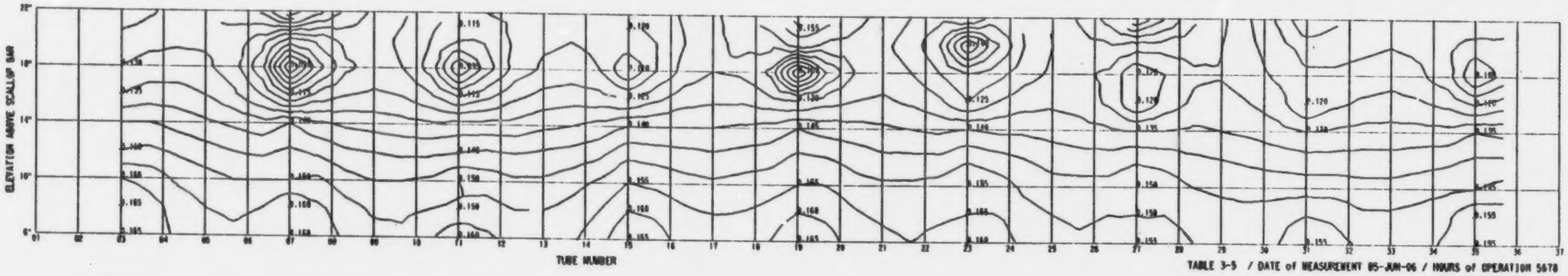


TABLE 3-5 / DATE of MEASUREMENT 85-JUN-06 / HOURS of OPERATION 5678

Monenco Consultants Limited	EMR 8277-5	DWG. No. EMR000193	Energy, Mines and Resources Canada Énergie, Mines et Ressources Canada	CONTOUR PLOTS OF TUBE WALL THICKNESS FBB-1/BED A/DRUM WALL

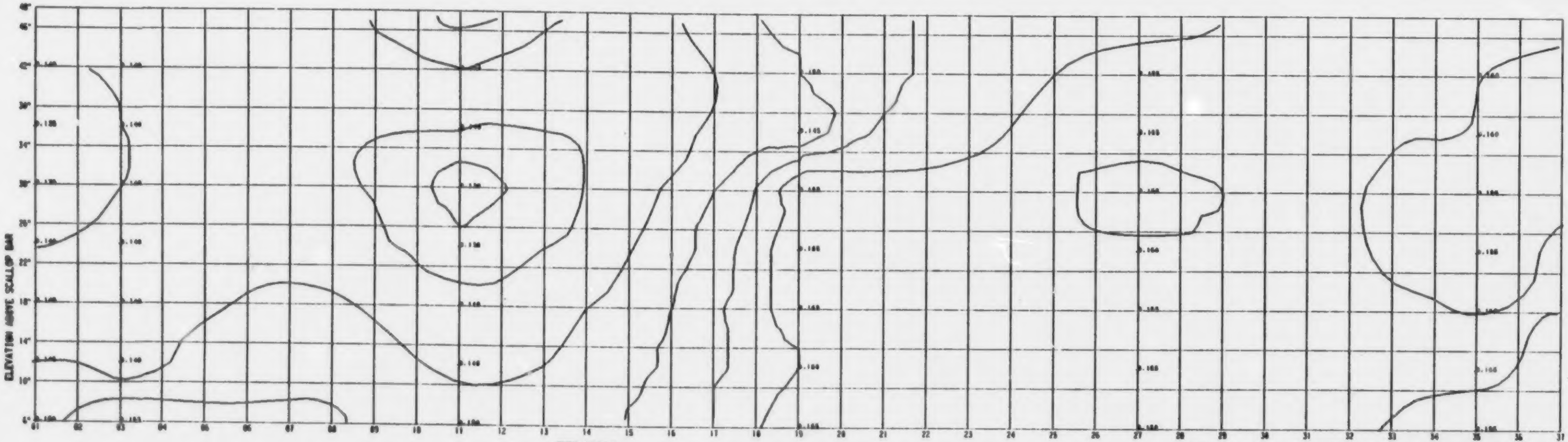


TABLE 3-6 / DATE of MEASUREMENT 83-FEB-28 / HOURS of OPERATION 539

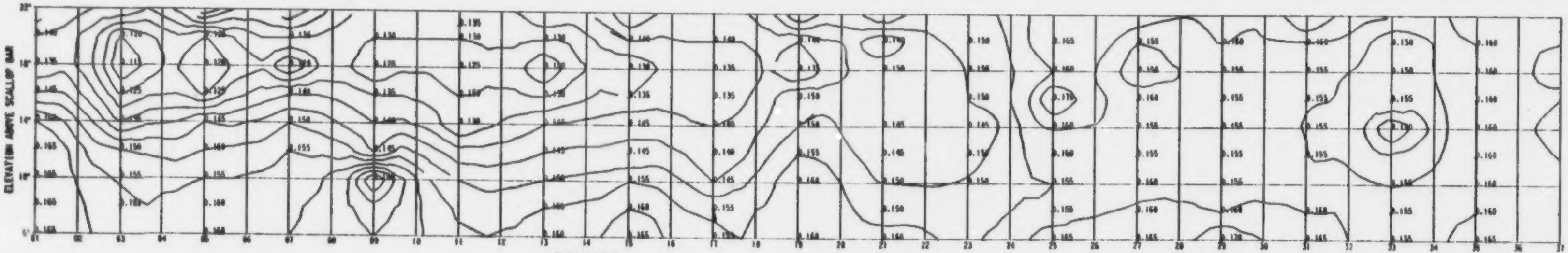


TABLE 3-7 / DATE of MEASUREMENT 84-JUL-18 / HOURS of OPERATION 3072

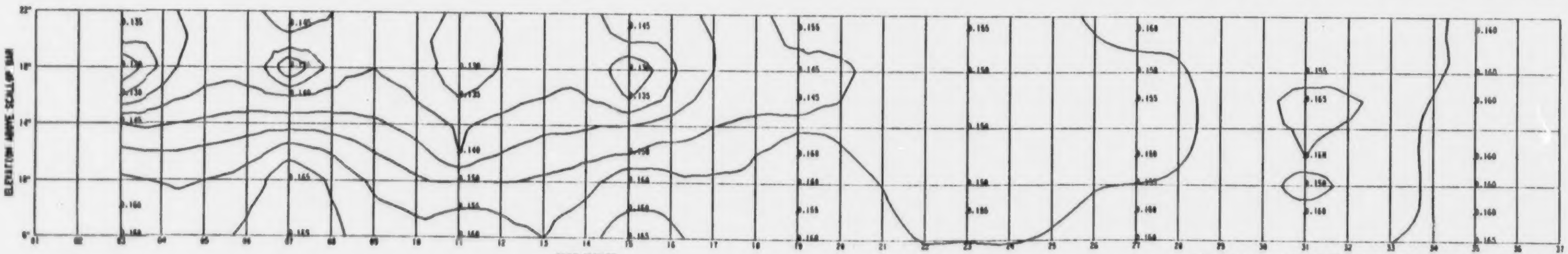
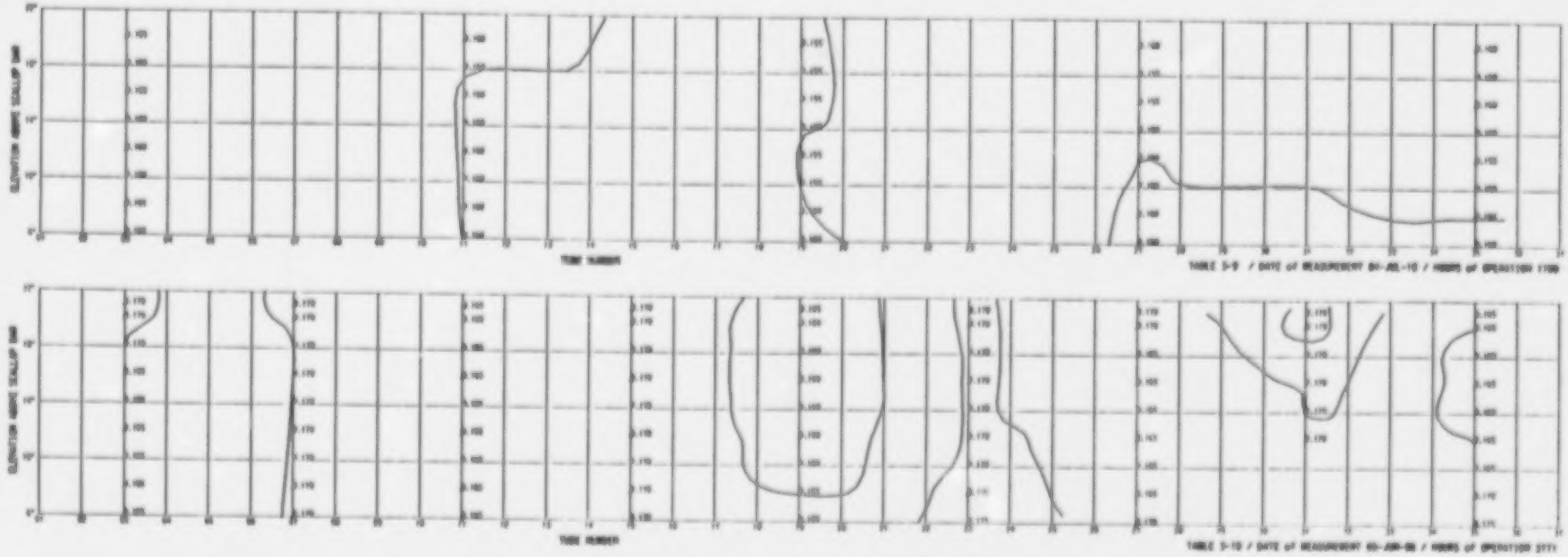


TABLE 3-8 / DATE of MEASUREMENT 85-JUN-06 / HOURS of OPERATION 5678

Monenco Consultants Limited	EMR 8277-5	DWG. No. EMR000194	Energy, Mines and Resources Canada Énergie, Mines et Ressources Canada	CONTOUR PLOTS OF TUBE WALL THICKNESS FBB-1/BED A/PARTITION WALL



Monenco Consultants Limited

EMR 8277-5

DWG. No. EMR000196

Energy, Mines and Resources Canada

Énergie, Mines et Ressources Canada

CONTOUR PLOTS OF TUBE WALL THICKNESS
FBB-1/BED B/FRONT WALL

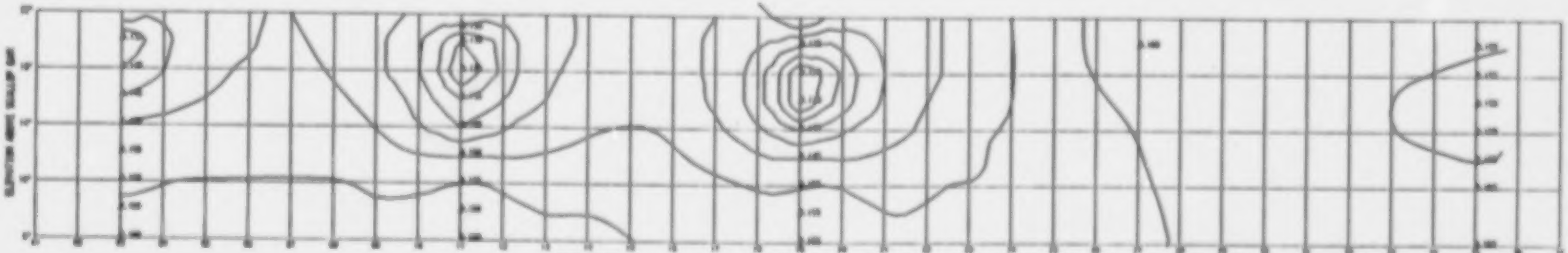


TABLE 3-11 / DATE of MEASUREMENT [illegible] / HOURS of OPERATION [illegible]

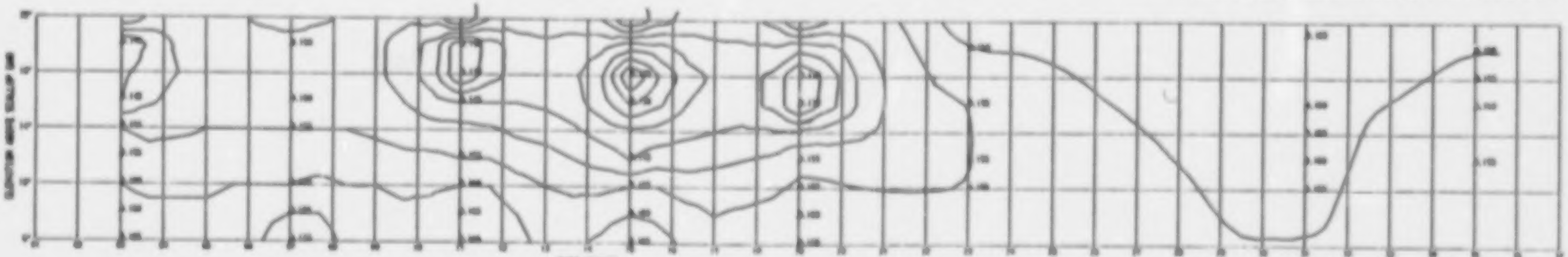


TABLE 3-12 / DATE of MEASUREMENT [illegible] / HOURS of OPERATION [illegible]

Monenco Consultants Limited	EMR 8277-5	DWG. No. EMR000195	Energy, Mines and Resources Canada Énergie, Mines et Ressources Canada	CONTOUR PLOTS OF TUBE WALL THICKNESS FBB-1/BED B/PARTITION WALL

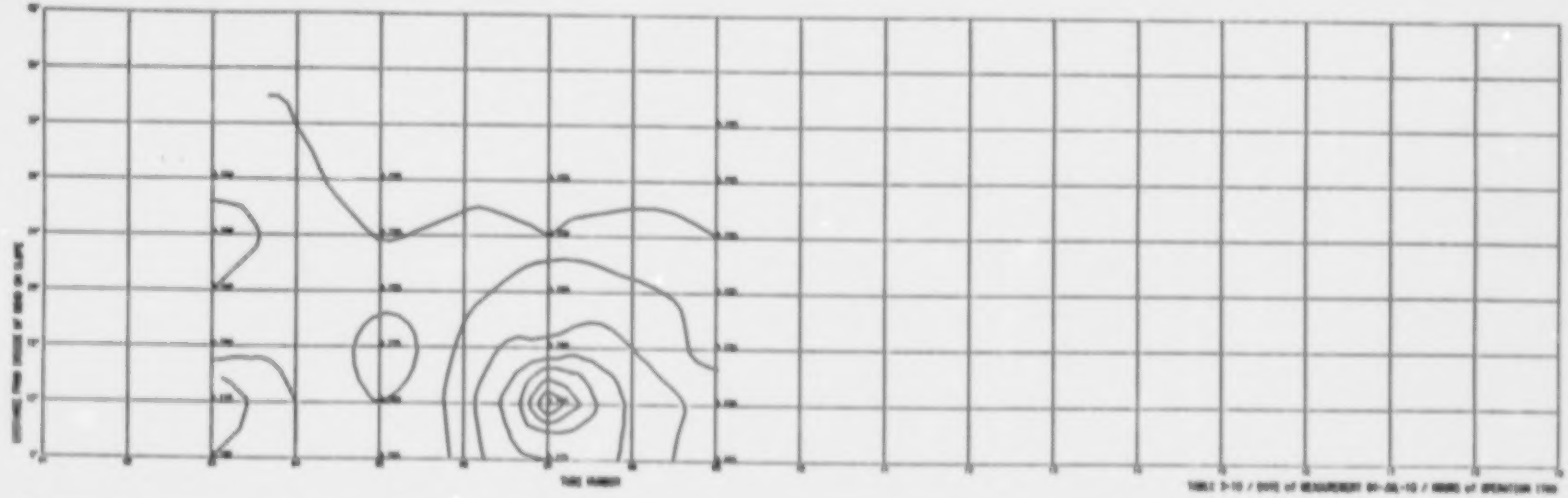


TABLE 3-10 / DATE of MEASUREMENT [illegible] / HOURS of OPERATION [illegible]

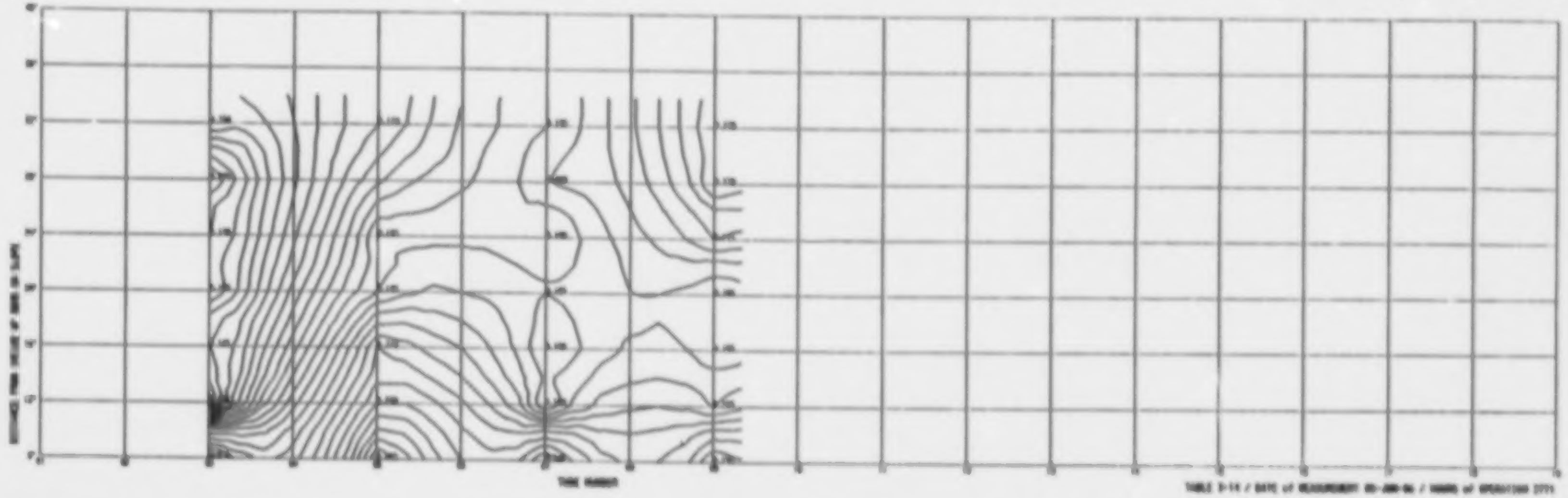


TABLE 3-14 / DATE of MEASUREMENT [illegible] / HOURS of OPERATION [illegible]

Monenco Consultants Limited	EMR 8277-5	DWG. No. EMR000197	Energy, Mines and Resources Canada Énergie, Mines et Ressources Canada	CONTOUR PLOTS OF TUBE WALL THICKNESS FBB-1/BED 8/IN BED TUBES

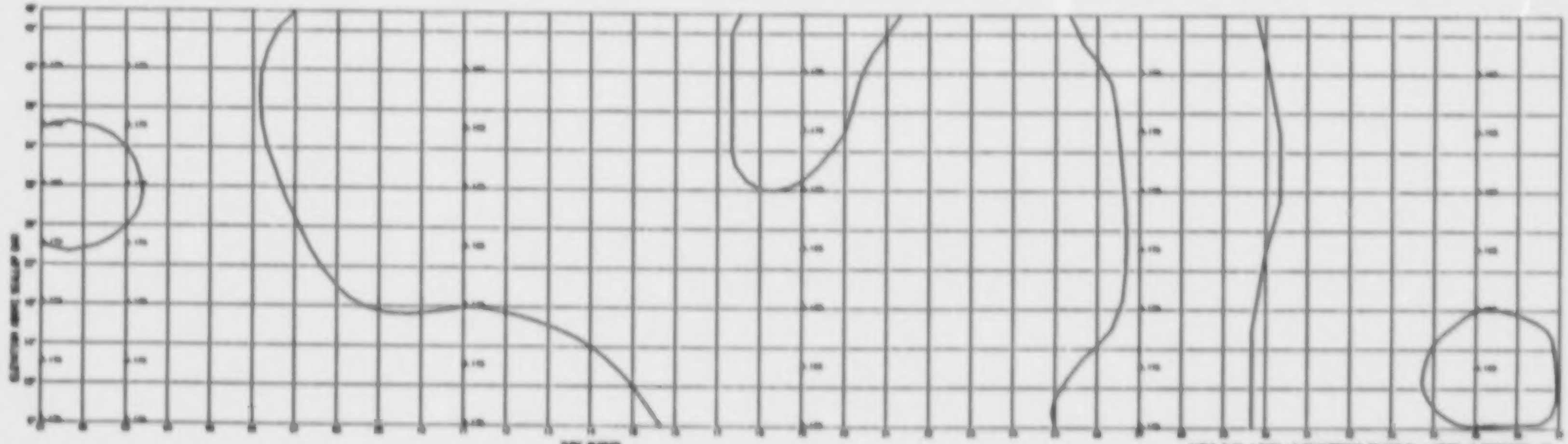


TABLE 3-15 / DATE of MEASUREMENT [illegible] / HOURS of OPERATION [illegible]

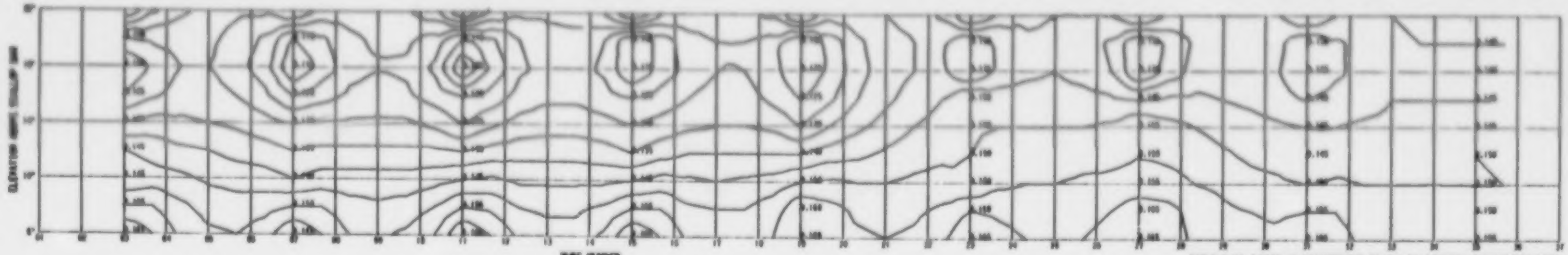


TABLE 3-16 / DATE of MEASUREMENT [illegible] / HOURS of OPERATION [illegible]

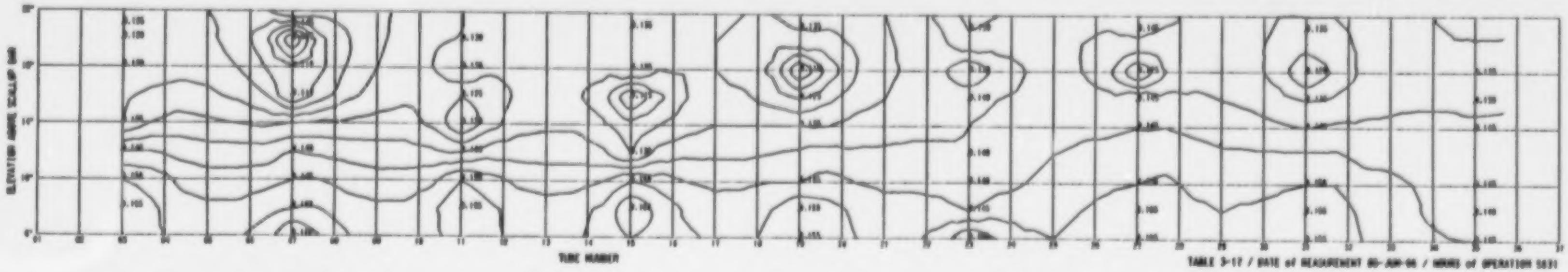


TABLE 3-17 / DATE of MEASUREMENT [illegible] / HOURS of OPERATION [illegible]

Monenco Consultants Limited

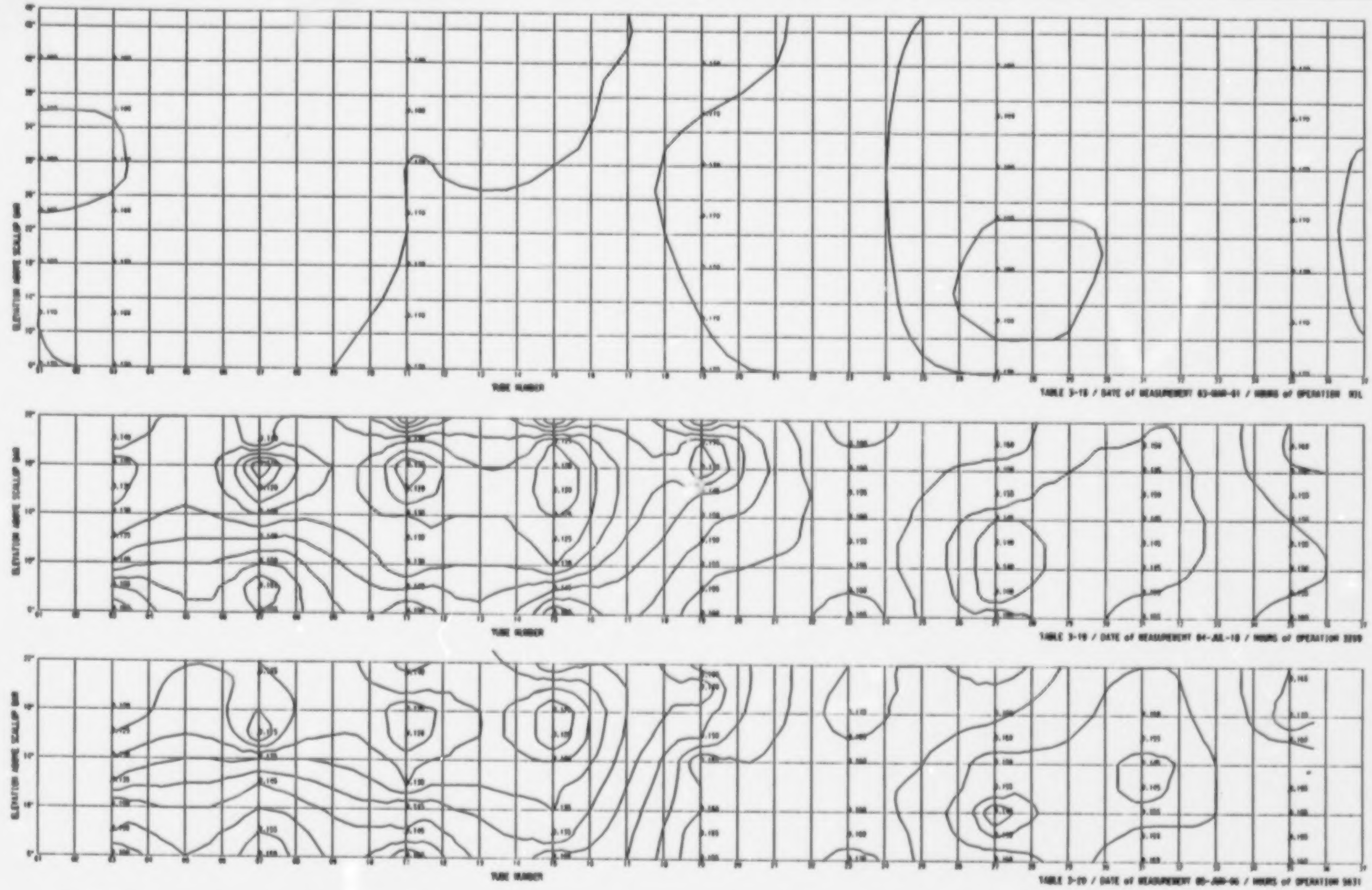
EMR 8277-5

DWG. No. EMR000183

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

CONTOUR PLOTS OF TUBE WALL THICKNESS
FBB-2/BED A/DRUM WALL

3-91



Monenco Consultants Limited	EMR 8277-5	DWG. No. EMR000186	Energy, Mines and Resources Canada Énergie, Mines et Ressources Canada	CONTOUR PLOTS OF TUBE WALL THICKNESS FBB-2/BED A/PARTITION WALL

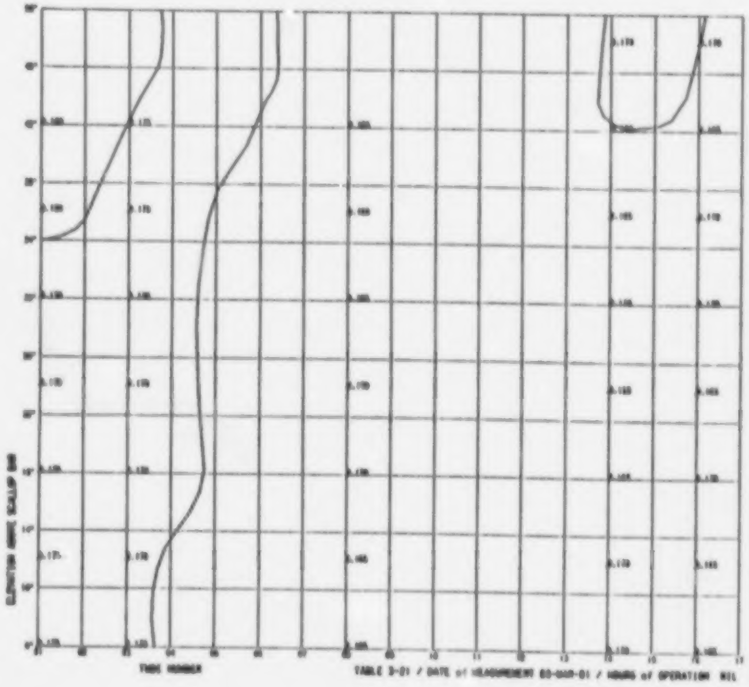


TABLE 3-21 / DATE of MEASUREMENT 83-MAR-01 / HOURS of OPERATION NIL

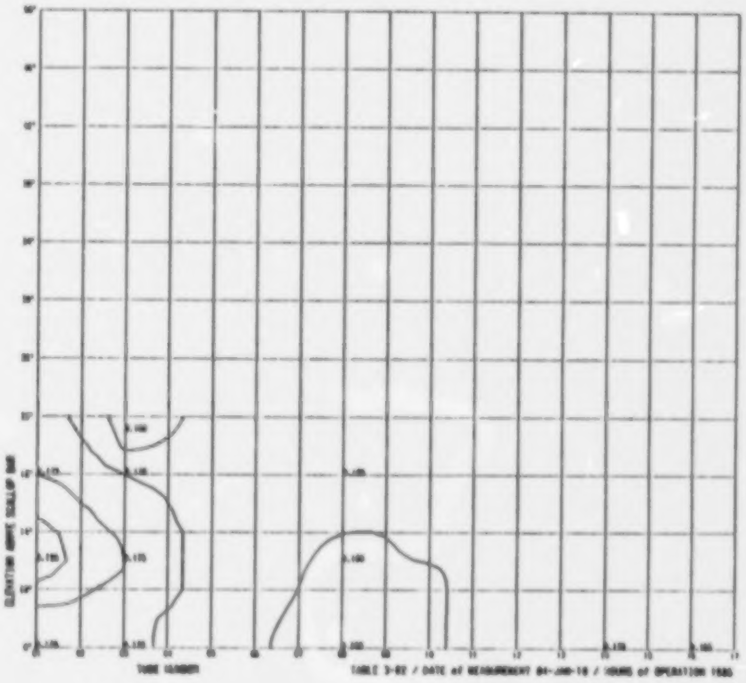


TABLE 3-82 / DATE of MEASUREMENT 84-JAN-16 / HOURS of OPERATION 1585

Monenco Consultants Limited

EMR 8277-5

DWG. No. EMR000185

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

CONTOUR PLOTS OF TUBE WALL THICKNESS
FBB-2/BED A/STOKER WALL

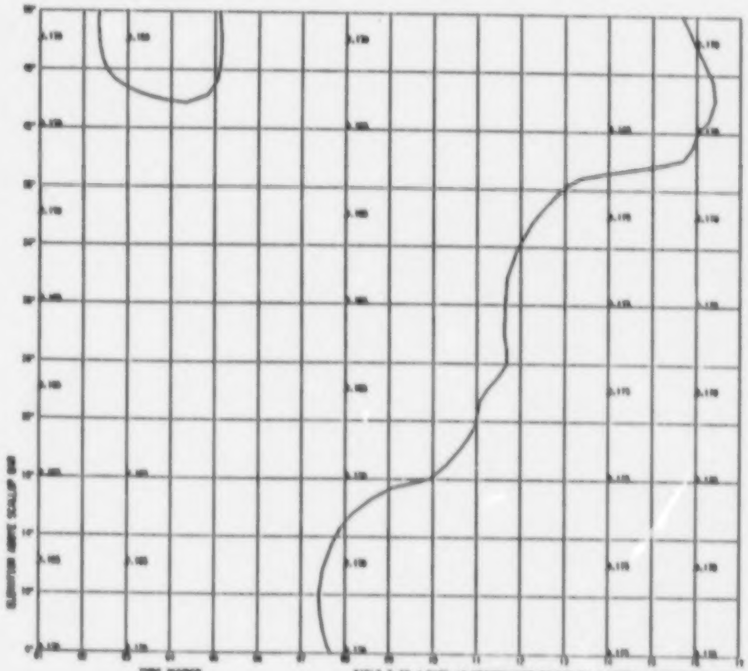


TABLE 3-23 / DATE of MEASUREMENT 83-MAR-01 / HOURS of OPERATION [illegible]

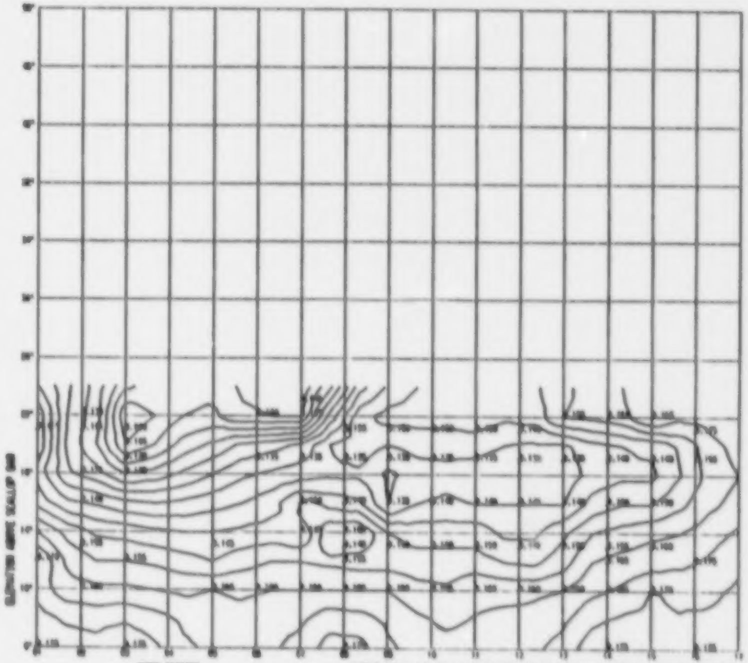


TABLE 3-24 / DATE of MEASUREMENT 86-FEB-14 / HOURS of OPERATION [illegible]

Monenco Consultants Limited	EMR 8277-5	DWG. No. EMR000184	Energy, Mines and Resources Canada Énergie, Mines et Ressources Canada	CONTOUR PLOTS OF TUBE WALL THICKNESS FBB-2/BED A/SORBENT INJECTION WALL

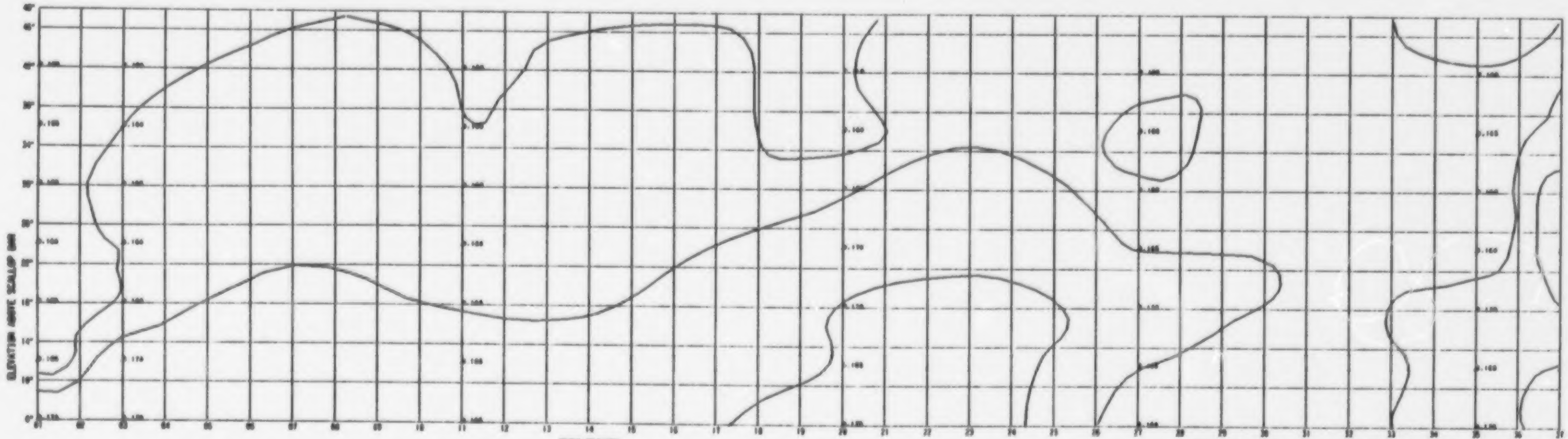


TABLE 3-25 / DATE of MEASUREMENT 03-MAR-81 / HOURS of OPERATION NIL

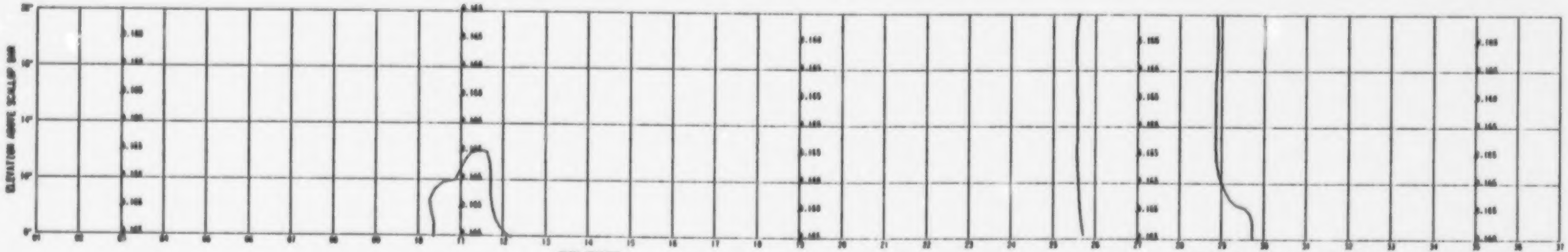


TABLE 3-26 / DATE of MEASUREMENT 04-JUL-18 / HOURS of OPERATION 1402

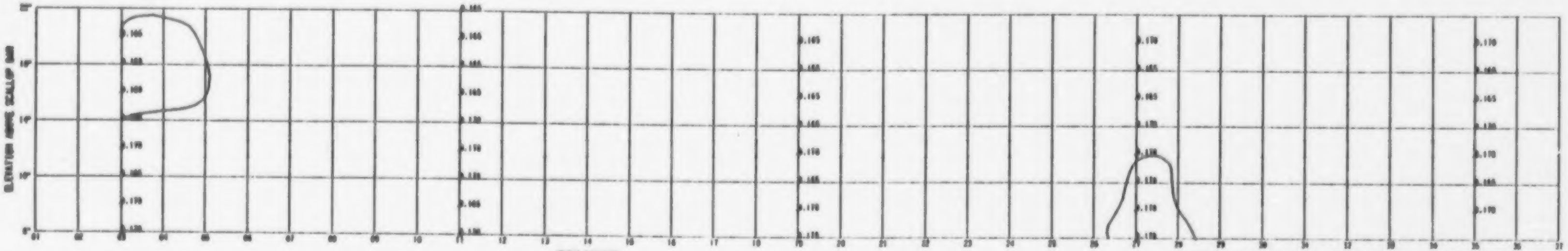


TABLE 3-27 / DATE of MEASUREMENT 05-JUN-85 / HOURS of OPERATION 3222

Monenco Consultants Limited	EMR 8277-5	DWG. No. EMR000190	Energy, Mines and Resources Canada	Énergie, Mines et Ressources Canada	CONTOUR PLOTS OF TUBE WALL THICKNESS FBB-2/BED B/FRONT WALL

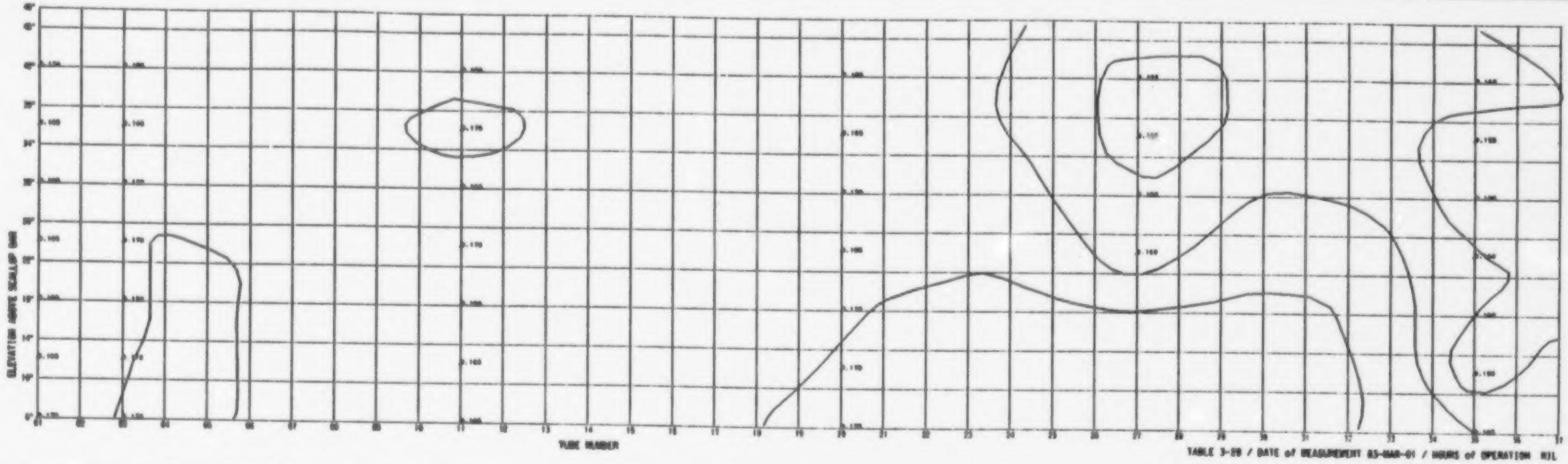


TABLE 3-28 / DATE of MEASUREMENT 83-MAR-01 / HOURS of OPERATION NIL

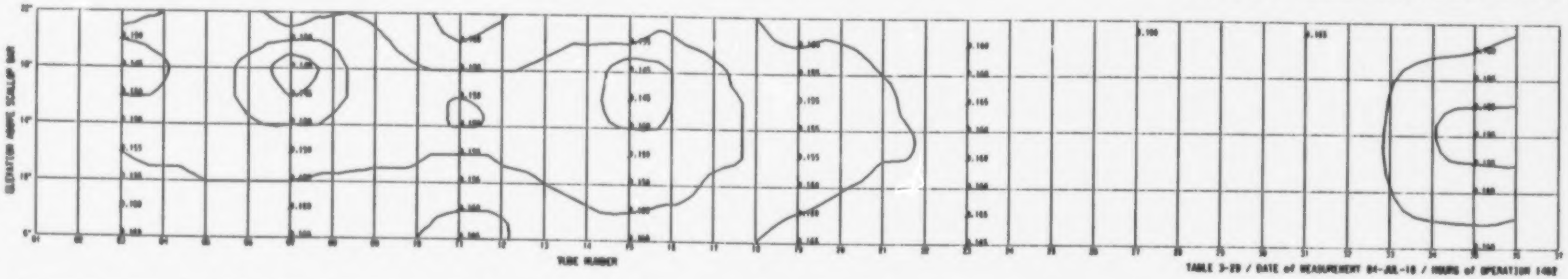


TABLE 3-29 / DATE of MEASUREMENT 84-JUL-18 / HOURS of OPERATION 1482

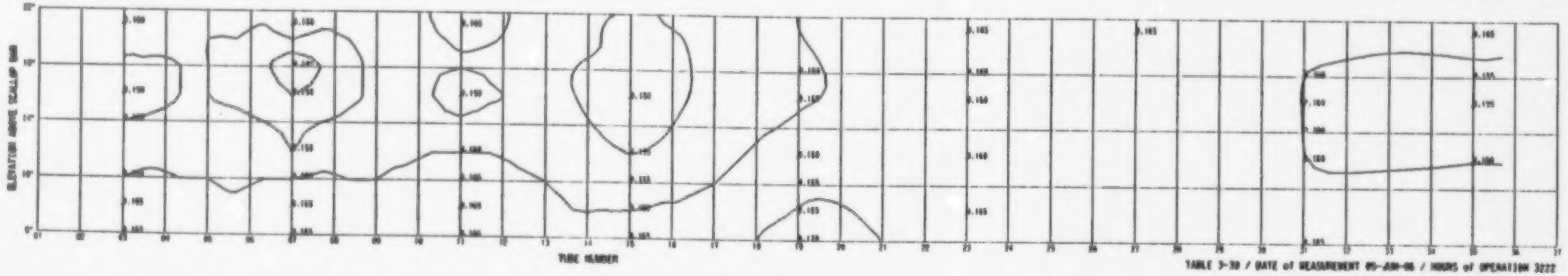


TABLE 3-30 / DATE of MEASUREMENT 85-JAN-06 / HOURS of OPERATION 3222

Monenco Consultants Limited	EMR 8277-5	DWG. No. EMR000189	Energy, Mines and Resources Canada Énergie, Mines et Ressources Canada	CONTOUR PLOTS OF TUBE WALL THICKNESS FBB-2/BED B/PARTITION WALL

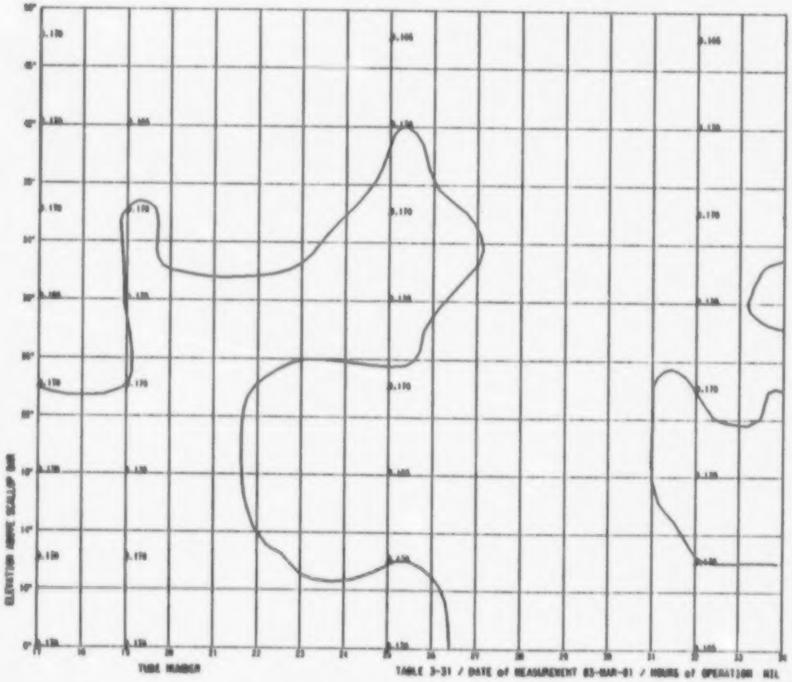


TABLE 3-31 / DATE of MEASUREMENT 83-MAR-01 / HOURS of OPERATION NIL

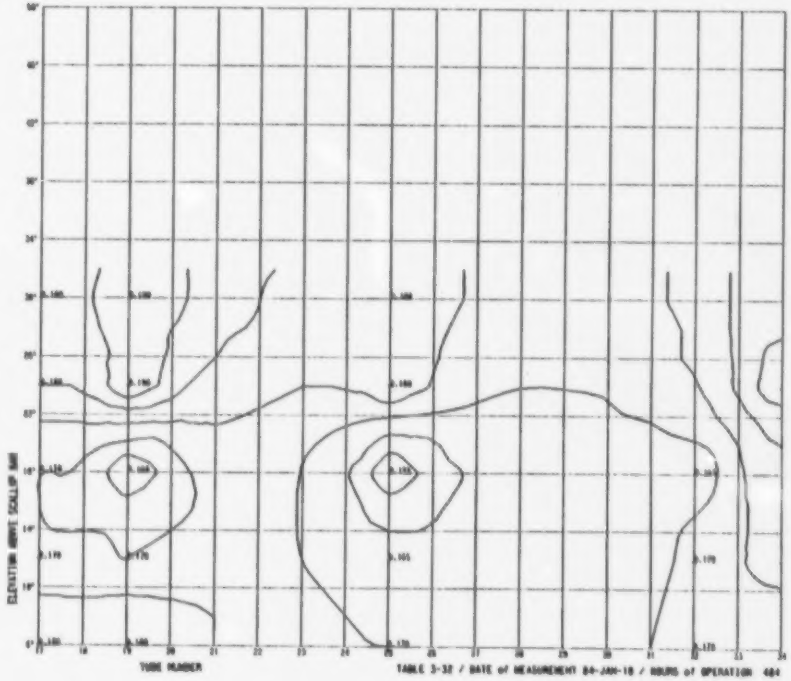
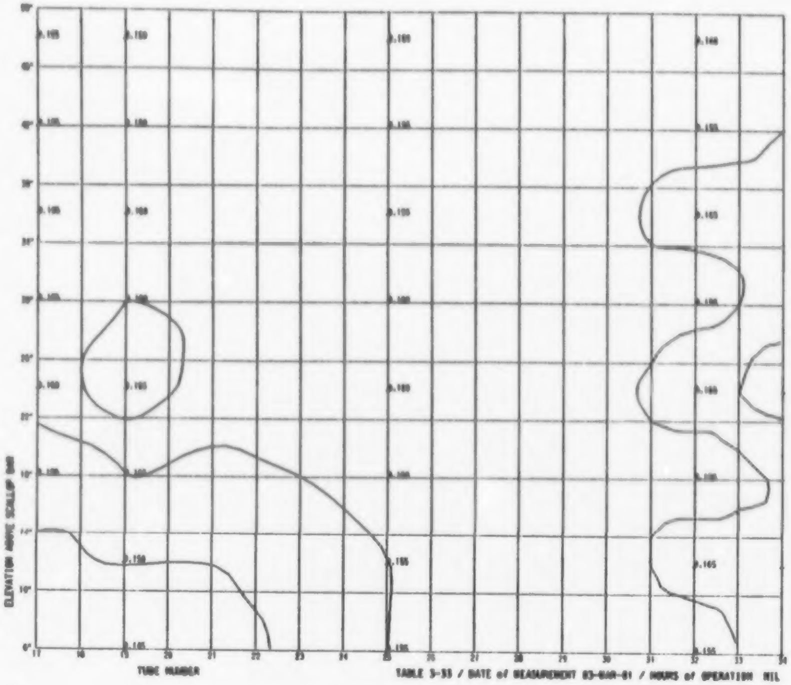
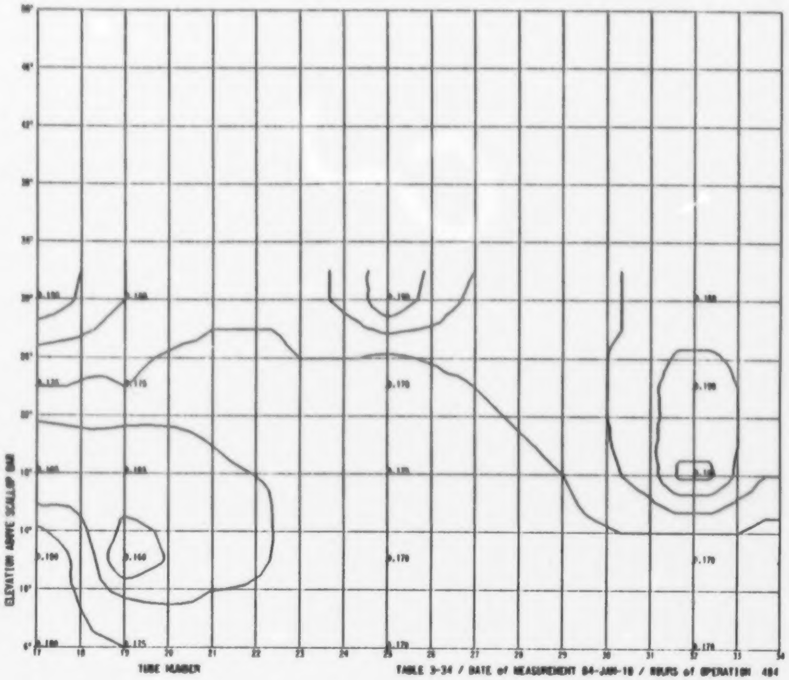


TABLE 3-32 / DATE of MEASUREMENT 84-JAN-18 / HOURS of OPERATION 484

Monenco Consultants Limited	EMR 8277-5	DWG. No. EMR000187	Energy, Mines and Resources Canada Energie, Mines et Ressources Canada	CONTOUR PLOTS OF TUBE WALL THICKNESS FBB-2/BED B/SORBENT INJECTION WALL	3-97





Monenco Consultants Limited | EMR 8277-5 | DWG. No. EMR000188 | Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CONTOUR PLOTS OF TUBE WALL THICKNESS
FBB-2/BED B/STOKER WALL

3-98

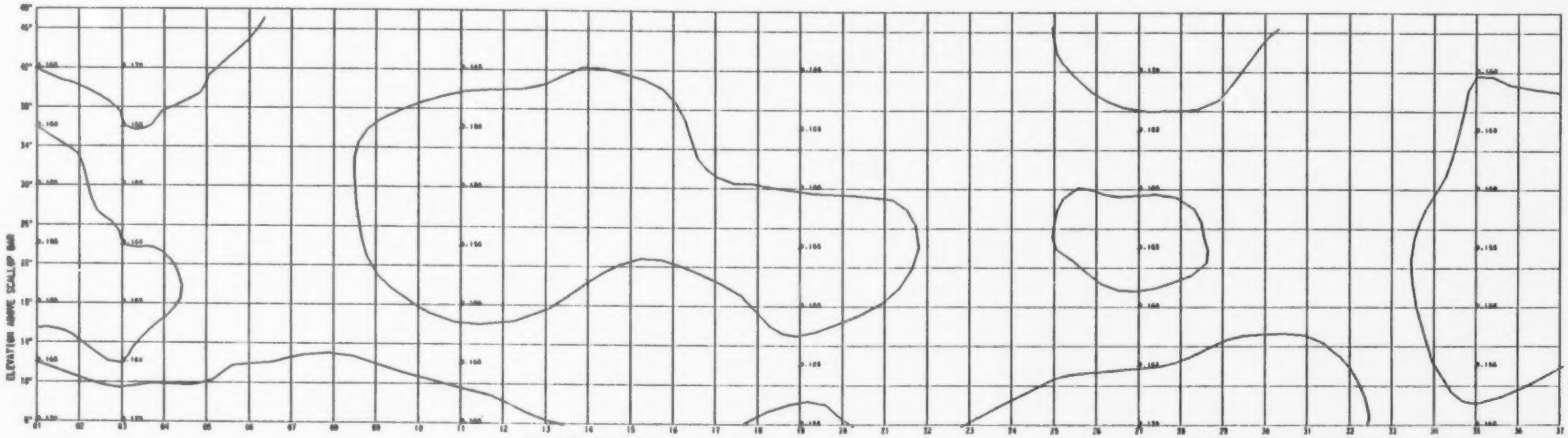


TABLE 3-35 / DATE of MEASUREMENT 03-MAR-20 / HOURS of OPERATION 412

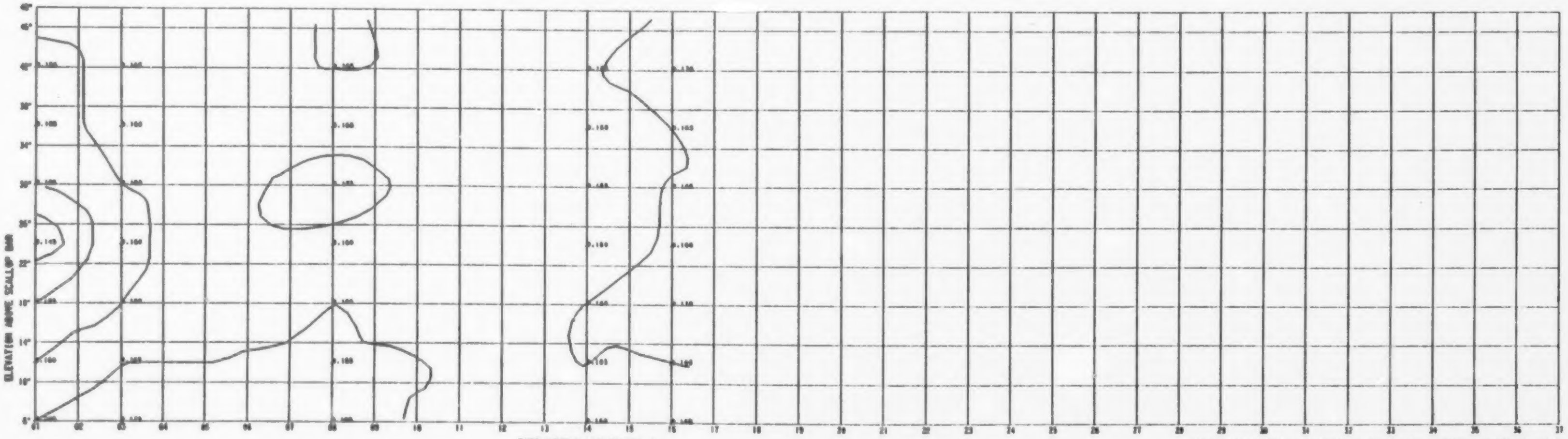


TABLE 3-36 / DATE of MEASUREMENT 03-MAR-20 / HOURS of OPERATION 412

Monenco Consultants Limited	EMR 8277-5	DWG. No. EMR000200	Energy, Mines and Resources Canada	Énergie, Mines et Ressources Canada	CONTOUR PLOTS OF TUBE WALL THICKNESS FBB-2/BED B/DRUM & STOKER WALLS	3-99

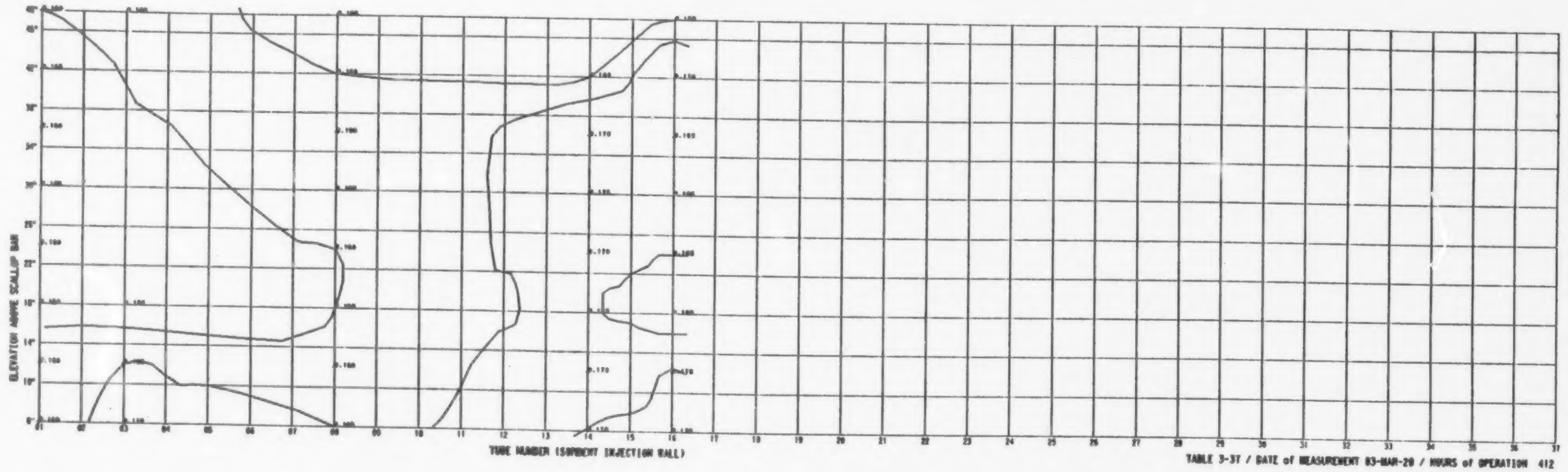


TABLE 3-37 / DATE of MEASUREMENT 03-MAR-28 / HOURS of OPERATION 412

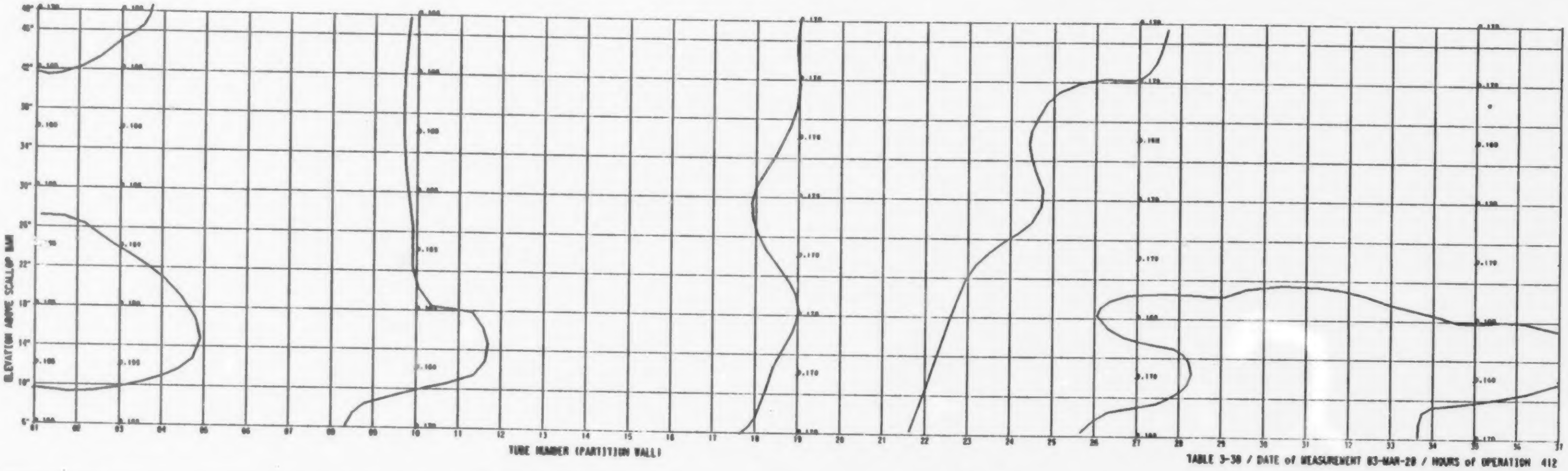


TABLE 3-38 / DATE of MEASUREMENT 03-MAR-28 / HOURS of OPERATION 412

Monenco Consultants Limited	EMR 8277-5	DWG. No. EMR000201	Energy, Mines and Resources Canada	Énergie, Mines et Ressources Canada	CONTOUR PLOTS OF TUBE WALL THICKNESS FBB-2/BED A/SORB.INJ.& PART'N WALLS

PART 4

PLANT OPERATION

INTRODUCTION

This part of the report evaluates the operation of the two fluidized bed boilers during the period December 1982 to June 1986, which covers almost four complete heating seasons.

The evaluation has been divided into two major sections as follows:

4.1 FLUIDIZED BED BOILERS
4.2 COMMON SYSTEMS

Each of these sections has been suitably sub-sectioned, as shown in the index, in order to cover all of its main areas.

This evaluation of plant operation confines itself to discussing those events, problems and solutions which are specific to the nature of a fluidized bed boiler plant as distinct from a conventional fuel-fired plant. Hence problems which could be expected to occur in any normal conventional boiler plant, if they were encountered during the operation of this plant, are neither mentioned nor discussed unless they happen to relate to, or highlight, a specific aspect of FBB plant operation.

4.1 FLUIDIZED BED BOILERS

A description of the fluidized bed boiler demonstration plant at CFB Summerside is given in Part 2.2 of this report. That description tallies with the "as constructed" status of the plant at the time of boil-out in November 1982.

Events during operation, and changes resulting from problems encountered in the course of operating the plant, are the subject of this part of the report. The problem of erosion and the measures adopted to mitigate and control erosion within the furnace are described in Part 3. Part 4 deals with all FBB operating problems, other than in-furnace erosion, during the same period of time, which is December 1982 to June 1986.

411.1 Ash Reinjection

As described in Part 2.2, the ash which is elutriated by the gases from the fluidized bed is classified, and collected for recycle of unburnts, in two locations. A first collection is made in the mud drum hopper, which is located below the boiler bank convection passes. The gases, still carrying heavy particles, then pass into a multi-cyclone dust collector where a second collection of the larger particles is effected prior to allowing the flue gases with their burden of fly ash to enter the baghouse via the economizer.

The convection bank recycle system consists of two conventional pneumatic eductors supplied with medium-pressure air from one positive displacement blower. Piping from each eductor terminates in one reinjection port in the furnace. The multi-cyclone dust collector was equipped with a batch-type double lock hopper reinjection system, called Permalok III, supplied by Ducon-Micropul, which discharged into the preferential bed through two reinjection ports. Transport air for the lock hopper system was provided by one positive-displacement blower. Thus the entire reinjection system for one boiler consisted of two eductors, one double lock hopper system, two blowers, four reinjection ports, and associated piping and controls.

The four ash reinjection ports (two from each system) enter fluidized bed 'A' just above the distributor plate in each boiler.

Problems with the ash reinjection systems manifested themselves early during initial operation of FBB-1 in December 1982 and January 1983, and similar problems were encountered on starting up FBB-2 in March 1983.

The problems experienced were of the following nature:

- Erosion

  Extremely high rates of erosion and wear of system components resulted from abrasion caused by the impingement of hot particles travelling at high velocities in an air stream.

  At one time or another, all components of the reinjection systems experienced excessive wear. For this reason blower speeds were reduced. However, even after the blower pressures and capacities were reduced, the rate of wear was unacceptably high.

- Excess Air

  An excessive amount of air was blown into the fluidized bed by the reinjection system. While this extra air did, on occasion, assist in fluidizing bed 'A', it was, on the whole, detrimental because it lowered bed temperatures by as much as 100°C, and thus contributed to difficulties in lighting-up.

- Mechanical Problems

  Mechanical problems were experienced with the Permalok double lock hopper components. Some minor mechanical problems were also experienced with the eductors, whose flanges leaked and had to be seal welded.

- Plugging of Transport Lines

  Plugging of transport piping was occasioned by clay and slate content suspected in the coal and limestone, combined with high moisture content. Plugging was experienced more often after blower pressure and capacity reductions were effected. Frequently the lines got plugged after shutdowns, due to undischarged material remaining in the system.

- High Noise Level

  Noise generated by the positive displacement blowers was unacceptably high. By changing sheaves in order to reduce discharge pressures to desired levels the noise level was reduced, but not enough. Additional noise level reduction measures were found necessary.

Each of these problems and their eventual solutions are discussed individually below, more or less in chronological order. The period covered is the same in each case, being almost four heating seasons, from December 1982 to June 1986.

EROSION IN THE ASH REINJECTION SYSTEMS

Reinjection From the Mud Drum Hopper

This system, which used simple pneumatic eductors, reinjected the ash collected in the mud drum hopper into bed 'A' of the boiler. All mechanical parts in contact with the air/particle stream were subject to erosion.

Air leakage at the eductor flanges was controlled by seal welding the flanges early in 1983.

The hot high velocity particle stream wore holes in the eductor bodies (housings). Temporary repair to them was carried out by patching with castable refractory.

It was soon realized that the reinjection system blowers were oversized, since the air from the reinjection systems was significantly lowering the temperature of bed 'A' in both boilers. Thus, it was expected that reducing blower capacity and pressure would simultaneously mitigate the problems of both erosion and excess air.

As a first step the 1 in. diameter nozzles in the eductors were changed to 5/8 in. diameter nozzles. This measure effectively reduced air supplied by this reinjection system to the furnace. However, since the blower capacity was unchanged, the reduction in nozzle size meant venting a higher proportion of the air discharged by the positive displacement blowers.

The next step was to reduce blower capacity and system pressure by changing sheaves on the belt drive. Photograph 40 (in Part 5 of the report) shows the reinjection system blowers and their electrical drivers.

By reducing blower air capacity and, consequently, particle velocity, the unacceptably high rate of erosion which had been experienced in the two months of initial operation was brought under control. But the problem was not altogether solved by these measures. During the period from March 1983 to June 1986 the ash reinjection system from the mud drum hopper, while operating more satisfactorily than before the changes, was still subject to continuing wear and had to be repaired frequently.

The following extracts from plant log give the reader an indication of the seriousness of the problem in relation to a time scale:

83/01/07

FBB-1: Replaced 1 in. diameter eductor nozzles with 5/8 in. diameter nozzles.

83/01/25

FBB-1: The piping leading from the eductors to the S.S. reinjection ports in the furnace had been offset near the furnace re-entry port during construction. This misalignment resulted in the entrained particles impinging on the port during re-entry and causing severe erosion. Since 3 in. S.S. pipe could not be obtained in time for the next shutdown, a temporary repair was effected using a castable refractory fill.

83/02/09

FBB-2: Replaced 1 in. diameter eductor nozzles with 5/8 in. diameter nozzles.

83/02/05 to 12

FBB-1: Found a hole eroded in the left hand eductor body (housing). The hole was patched and then the eductor was boxed in using 8 in. pipe filled with Greencast 94 refractory.

A similar hole was found worn in the right hand eductor body, and it was similarly repaired.

Couplings were found leaking on the pipe transport system. They were boxed in and Greencast 94 refractory poured in to seal the leaks.

Refractory was repaired around leaking reinjection piping.

Reinjection nozzles (ports) on the furnace were found to have worn, and were patched.

83/02/11 to 16

FBB-2: Worn reinjection nozzles (ports) were removed from the furnace and new ones were installed.

83/03/21

FBB-2: Eductors bodies were found to be worn and were patched with Greencast 94 refractory.

83/03/29 through 84/05/01

FBB-2: In March 1983 severe erosion wore away all but 2 to 3 in. of the original eductor throats. A 3 in. pipe was, therefore, slipped over the throat and welded to the body, with the pipe terminating in a flange at the same location as the original length of the eductor. The outside of the box was then lined with Lavalox refractory.

Since then no further wear has taken place inside the eductor throat. There is very little wear on the body of the pipe which was installed to replace the worn part of the eductor. However, the pipe has worn through at the flange at the discharge end, with the wear starting at the flange joint. Where the pipe has worn through, the wear on the Lavalox is greater, indicating that it will not stand up to long service as initially thought.

83/06/02

FBB-1: The stainless steel reinjection pipes have a 4 in. hole worn in them where they were bent to fit, and the eductors have 5 in. long holes worn in their sides.

83/12/22

FBB-1&2: Inspected and repaired a section of reinjection nozzle piping outside the furnace by cutting away worn sections and patch welding.

84/01/13

FBB-1&2: Carried out replacement of worn nozzle ends and realignment of inlet piping.

84/02/28

FBB-2: On inspecting the eductors it was found that the reinjection stream has worn through the eductors and cut about 1/2 in. into the Lavalox refractory lining at the discharge end. The 5/8 in. steel nozzle is also worn across the top where the air enters the eductor.

84/03/22

FBB-1: Found an eductor leaking at its flange. Welded a plate over the leak and sealed it with Lavalox refractory. The second eductor was similarly repaired.

84/07/17 to 30

FBB-1&2: Replaced all reinjection nozzles (ports) in both furnaces.

85/10/25

FBB-2: A leaking flange was repaired on the reinjection system.

86/01/07

FBB-1: Small holes worn in the reinjection system transport piping were weld repaired.

Finally, in the summer of 1986, the eductors and associated piping were removed, and a "Z" bend system of reinjection piping, which had been tried and operated successfully on the reinjection system from the multi-cyclone hoppers, was installed. The latter system is illustrated in Figure 4-1 and is shown in Photographs 28, 29 and 30 in Part 5 of this report.

Reinjection from the Multi-Cyclone Dust Collectors

This system consisted of "Permalok" double lock hoppers leading into pipe transport systems containing numerous bends elbows, offsets, and couplings and ending in ash re-entry ports in fluidized bed 'A', located just above the distributor plate.

Every component of the system was subject to erosion by the hot high velocity particle stream. In the early stages of initial operation, before the blower capacity and pressure were reduced, the reinjection system could not withstand even a week of boiler operation without erosion-related repairs being made to system components. After the reduction in blower speed the rate of erosion was reduced, but the maintenance and repair demanded by the system was still unacceptably high.

The following extracts from plant operating logs and project correspondence give the reader a time-scaled perspective of the extent of the problem encountered:

83/02/07

FBB-1: Permalok hopper gaskets are leaking.

83/10/30

FBB-2: During the night a hole wore through on the transport pipe between the splitter box and the right side reinjection port. Later another hole appeared in the pipe to the left side reinjection port. The bed was slumped and temporary repairs carried out.

83/11/23

FBB-1: Reinjection system was shut down to repair a refractory seal in an elbow of the transport system.

83/11/25

FBB-1: One of the couplings on the reinjection system transport piping is leaking and needs replacement.

83/11/27

FBB-1: A coupling was moved to temporarily cover a hole eroded in a nozzle (re-entry port). The nozzle will need to be repaired later by replacing the worn section and improving the alignment of the piping to reduce or prevent further wear.

83/12/22

FBB-1&2: The outside portions of an ash reinjection nozzle (re-entry port) were inspected and found to need repair.

84/01/12

FBB-2: Disconnected and inspected re-entry nozzles (ports) after removing the couplings on the reinjection system piping. All nozzles are eroded at the top about 3 in. in from the joints. All inlets to the nozzles are misaligned, being too low at the entry. The ends of all nozzles will be replaced and the inlet pipes realigned.

84/01/17

FBB-1&2: Excessive wear in the splitter boxes was discussed with the supplier (Ducon Micropul). The splitter box accepts flow coming in a single pipe from the Permalok hoppers and divides it into two streams each of which is piped to a separate reinjection nozzle (port) in the fluidized bed 'A'. Ducon recommend a reduction in air velocity in the splitter to allow material build-up in the box so as to allow it to develop its own internal contouring and thus prevent erosion. This requires that sheaves on the motor drive of this system also be changed.

Discussions with the supplier have also revealed that the excessive wear on the Johnson couplings has primarily been due to poor machining quality control leading to poor

I.D/O.D. matching, so that leaks at the coupling junctions have resulted in high wear.

84/03/08

FBB-1: The reinjection system is leaking because the coupling between the stainless steel nozzle (re-entry port) and the cast iron elbow was loose, permitting material to cut through the gasket and leak out.

84/04/03

FBB-1: The elbow on the vent line between the Permalok hopper and the equalizer valve has worn out. This valve vents the upper Permalok chamber to the duct which leads to the baghouse.

Note: During the 1984-85 heating season the solenoid valve on this vent line eroded, allowing particles, which were intended for reinjection, to be blown into the flue gas breeching upstream of the baghouse every time that the lock hopper was under discharge. It happened at this time that several bags were broken, and these coarse particles were therefore sucked in through, and eroded, the I.D. fan, resulting in so much damage that the whole fan had to be replaced after that heating season.

84/07/17 through 84/08/07

FBB-1&2: All reinjection nozzles (re-entry ports) were worn away during the 1983/84 heating season. New ports were made, installed and the reinjection piping was sealed with refractory.

As the chronological account quoted above indicates, while the most severe phase of the erosion problem was overcome, and high rates of wastage in the reinjection system from the multi-cyclone hoppers to the furnace were brought under a measure of control, the long term problem of erosion in this system had not been solved.

In the summer of 1985, the fly ash reinjection system serving the multi-cyclone collector on FBB-2 was replaced with a much simpler system employing a modified L-valve such as is commonly applied to a circulating fluidized bed combustor. The new system consists of two pipes 6 in. in diameter, each connecting one of the multi-cyclone hoppers to one of the reinjection ports in the furnace wall. The pipes have a "Z" section at the lower end, as shown in Figure 4-1, to form a seal against the static pressure of the fluidized bed. Fly ash flows by gravity from the multi-cyclone hopper down the inclined pipe, is lifted over the "Z" section by small amounts of air injected at the lower elbow, and is then injected into the bed by an air nozzle located in the reinjection port. Thus, except for the injection nozzles at the boiler walls, the entire system operates at low velocity, with a minimal potential for erosion.

Since the flow of air through the injection ports is relatively small, it is supplied from the positive displacement blower serving the convection bank reinjection system, and the blower which formerly served the double lock hopper system is no longer required.

At the onset of the 1985/86 heating season, it was demonstrated that the new system performs well in every respect. Upon failure of the air supply it is self-sealing, and subsequently can be restarted without difficulty. Similarly, on a few occasions the boiler was operated on Bed 'B' only, which meant that fly ash recycle had to be interrupted until Bed 'A' was put back in service. That situation, too, was handled without difficulty. The reinjection nozzles were inspected after 2500 h and 4500 h of operation, and showed no signs of erosion.

In November 1985 the same system was installed on FBB-1, and subsequently the double lock hopper systems have been dismantled. The elimination of one recirculation blower per boiler has reduced the noise level in the plant.

EXCESS AIR

The fluidized beds have not at any time operated at the design figure of 22% excess air. A substantially higher level has always been required to control bed temperature. During January 1983, in the shakedown period, the operators attempted to use reinjection air to help overcome the difficulties they encountered in fluidizing bed A. However, this expedient proved counter-productive. The reinjection air lowered bed temperature, caused uneven bed level by blowing bed material towards the partition wall, and created so much dust that the operators could not see the bed as it is necessary for them to do in order to control light-up procedure. For these reasons, reinjection air was not thereafter used to assist bed fluidization. As described later in Part 411.32, fluidization on cold start-up was eventually facilitated by installing extra nozzles in the preferential beds.

REINJECTION SYSTEM MECHANICAL PROBLEMS

Mechanical problems encountered related mainly to the actuating mechanisms and limit switches in the 'Permalok' double lock hoppers of the ash reinjection systems from the multi-cyclone dust collectors.

At the time of initial operation of FBB-1 (January 1983) it was discovered that seal air had not been provided as required by the supplier (Ducon Micropul). As a consequence the upper valve bushing and shaft seal had to be replaced. Needle valves controlling air cylinder action of the lock hopper valves were adjusted so as to slow down the cylinder action as much as possible.

Despite changing of sheaves on the motorized drives to reduce blower speed, it was found that air still had to be vented in order to hold down air-particle velocities in the reinjection system and reduce excess air supply to the furnace.

In January 1984 a meeting was held with Ducon Micropul at site. At this meeting Ducon stated that, as a result of the problems experienced with the Permalok equipment, a number of design changes had been made. These design changes had resulted in modifications to a number of components, principally involving seats, discs, inside clevice arm, bushing insert assembly, shaft and spring. They stated that the new parts, manufactured to revised specifications would be available at the end of January 1984. The Permalok valves could then be disassembled during a shutdown and re-assembled with the new parts. Ducon also advised the plant to carry two sets of spares, based on the new design. One set would include the following at a cost of $5,580.00:

4	Part No. 3T9-58 gate discs
2	Part No. 3T8-48-1 Ni-hard seats

2 Part No. 3T8-48 ceramic seats
2 Part No. 3T8-43 crank arm bearing
8 Part No. 4T9-73 crank arm packing
1 Part No. 4T1-37 limit switch
1 Part No. 4T1-035 air cylinder
1 Part No. 4T1-051-1 solenoid valve
3 Part No. T1274 equalizing valve packing
1 Part No. 4T8-55 equalizing valve seat

The following extracts from plant logs give a rough indication of the frequency of mechanical problems:

84/03/08

FBB-1: The top Permalok air cylinder was found to be leaking around the shaft. A new shaft seal is required.

84/04/06

FBB-2: A limit switch had to be replaced once more on a Permalok double lock hopper.

84/04/10

FBB-1: Permalok equalizer valve was found to be leaking. On tightening, the housing broke. Repairs were made.

PLUGGING OF REINJECTION SYSTEM TRANSPORT LINES

The ash reinjection system transport piping sometimes got plugged with material. There appear to have been two main causes of plugging.

- System component failure.

- Shutdown under upset conditions. (The ash would normally be very dry. However, if the system sat with full lines for a day or two, CaO in the ash would pick up moisture and cement.)

On the whole the plant logs indicate that the reinjection system functioned smoothly during steady boiler operation. However, on occasion, the dust collector hopper, the transport lines or the ports did choke up independently of boiler upsets. The following extracts from plant logs indicate the frequency and cause of failure:

83/11/23

FBB-1: Plugging in the re-entry nozzle of the mud drum hopper reinjection system was cleared.

84/01/20

FBB-1: On starting the reinjection system from the multi-cyclone dust collectors the transport lines were found to be plugged. The system was shut down, the lines cleared. The trouble was caused by failure of the valves to close properly. This allowed the lines to become full of material while the blower was out of operation.

The lower valve was reset and the system restarted.

84/02/21

FBB-2: One eductor on the mud drum hopper reinjection system was plugged, but fortunately cleared on being pounded.

84/04/17

FBB-2: Drained FBB-2 'A' bed. Turned on the multi-cyclone reinjection system to clear the dust collector hoppers, and found the lines plugged. Vacuumed them out.

85/01/08

FBB-2: On restarting FBB-2 the ash reinjection system was found to be plugged. It took a great deal of time and trouble to clear it.

85/01/10

FBB-1: The ash reinjection system plugged frequently due, it was suspected, to the coal containing a high proportion of slate.

85/12/14

FBB-1: When the boiler was brought on line the ash reinjection system kept plugging up and then suddenly releasing, causing boiler fluctuations. Bed temperature and steam flow were erratic. Then it settled out on its own.

86/01/07

FBB-1: Ash reinjection lines plugged up a few times.

86/02/09

FBB-1: The ash reinjection hopper got choked. On clearing the choke, the reinjection system started and put out the fire in bed 'A'. Had to re-ignite.

86/02/20

FBB-2: Ash reinjection hopper choked and lines full.

86/03/19

FBB-1: Ash reinjection lines plugged repeatedly through the night. Removed about twenty barrels of ash from the hopper.

86/04/06

FBB-2: Ash reinjection system plugged up. Coal like asphalt.

HIGH NOISE LEVEL FROM REINJECTION BLOWERS

The reinjection system blowers were extremely noisy. A reduction in noise level was achieved by speed reduction in 1983, but a noise survey carried out by Higgott-Kane in March 1984 still reported very high noise levels 1 meter from the equipment, as follows:

50 HP Rotary Positive Blowers - 107 dBA

25 HP Rotary Positive Blowers - 105 dBA

The design modifications to the reinjection system carried out in 1985 and 1986 as indicated in Figure 4-1 and Photographs 28, 29 and 30 have resulted in cutting down air supply and pressure requirements for the reinjection system, making it possible to supply both the boiler bank reinjection system and the multicyclone collector reinjection system with air from the 50 HP blower. This has also resulted in noise reduction. In the 1985-86 heating season a significant reduction in noise was achieved by installing a soundproof enclosure over the reinjection blower.

411.2 Stokers

The stokers were designed to feed both plant fuels, coal and wood, to the furnace.

Wood firing was attempted briefly once for a few hours, and a second time on demonstration/test basis for warranty purposes, in order to prove that the boiler can deliver an agreed performance when burning only wood in bed 'A'. During these periods the stoker performance on wood was entirely satisfactory.

The stokers had, and continue to have, serious problems feeding coal to the furnaces. The problems may be classified broadly as follows:

- Mechanical problems.

- Bed material backing up into stokers.

- Plugging of tuyeres.

- Rotor stalls caused by excessively wet and fine coal.

These problems are discussed below in the listed order:

MECHANICAL PROBLEMS

Some mechanical problems were experienced in early operation, but soon put right. For example, it is reported in the log that on the very first day of commissioning, 29 November 1982, "The speed sensor threading was damaged on start-up". However, this was satisfactorily repaired. On 8 June 1983 a taper fit on the stoker drive shaft pulled loose and the stoker stopped running, although its drive motor continued to operate. Repair was satisfactorily effected.

By sheave change the stoker rotor speed on FBB-2/A has been decreased just prior to start-up for the 1986-87 heating season, and this is reported to have resulted in improved stoker performance by increasing rotor torque.

There have been no further mechanical problems, other than one rotor bearing being worn and changed.

BED MATERIAL BACKING UP INTO STOKERS

This problem was occasional during early operation when bed level was maintained excessively high, but was quickly overcome by improved bed and reinjection system management.

PLUGGING OF STOKER TUYERES

Air is fed to tuyeres which are located strategically to keep the stokers clear of coal fines. Once in a while (viz. 84/03/05: FBB-1 and 84/02/20: FBB-2) the tuyeres are reported to have clogged up with coal fines. It was clearly not a serious or very frequent problem.

ROTOR STALLS CAUSED BY EXCESS OF WET FINES AND POOR COAL QUALITY

This problem has, and continues to, plague the stokers. An excess of fines combined with poor coal quality, outdoor storage and handling, have troubled all the coal handling, storage and feed systems. This problem still exists today even when coal with relatively low moisture content is delivered directly into the plant.

The persistent nature of the problem is obvious from the following record:

Date	Boiler No.	Log Record
84/03/15	FBB-2	Boiler shut down due to coal pluggage and stoker problems arising from trying to move wet coal.
84/03/27	FBB-1	Sticky coal build-up around the stoker shaft and pan housing causing stoker motor trips.
84/03/28	FBB-2	Sticky coal stalls the stoker rotor. The day bin and pantleg were full of this coal, which had dried to a solid mass and had to be chipped out. The pan below the rotor had to be repeatedly removed and cleaned, and was finally left off so that the fines piled up on the floor (see Photograph No. 45). Once we were able to feed good coal from the bunkers we had no problem with the stokers. This is the first

Date	Boiler No.	Log Record
		time we have had coal that caused so many stoker problems.
84/04/03	FBB-2	Coal fines plugged stokers all day.
84/04/04	FBB-2	Asphalt-like coal kept plugging stokers all day. Six 3/16 in. holes were drilled in the stoker air chamber just above the rotor, in the hope this will keep fines out of the rotor pan.
84/04/05	FBB-2	Opened stoker air dampers that feed air to a slot under the chain conveyor. Coal is like plasticene and stops both stoker rotors, more often the bed 'B' stoker.
84/04/06	FBB-2	Air jets have been added to 'B' stoker pan to prevent build-ups which stall the rotor.
84/04/25	FBB-1	Coal is still sticking to rotor pan and stalling the rotor though the air jets have reduced the frequency of stalls.
84/04/26	FBB-1	Problems all day with stokers due to clay in the coal. This coal also causes baghouse problems.
84/12/16	FBB-2	Stoker stalled twice on FBB-2/A.

Date	Boiler No.	Log Record
85/01/10	FBB-1	Stoker problems caused by suspected slate in coal.
85/01/22	FBB-2	One stoker stall during performance testing.
85/01/23	FBB-2	Numerous stoker stalls during performance testing.
85/02/19-23	FBB-1	Numerous stoker stalls all day due to poor quality (fine and wet) coal. Pans of both stokers were removed. Operator's comment: "This coal might make good asphalt, but (it) is not good coal". Removal of pans caused fines to fall on the floor and then get into the drains, which got choked. Hosing the drains got water into cable trays. A real mess.
85/10/10-11	FBB-2	Two stoker stalls on 10th and one on 11th.
85/11/03,12, 23,28	FBB-2	One stall on 3rd. Stalls all day on 12th. One stall on 23rd and one on 28th.
85/12/11,12	FBB-2	Repeated stoker stalls caused drop in bed temperatures. The new coal delivered was very poor. Bed temperature variations caused drum level control problems, and feedwater had to be operated on manual.

Date	Boiler No.	Log Record
85/12/20	FBB-2	Stoker problems on both beds.
86/01/02,05,08, 25,26	FBB-2	Numerous stoker stalls despite keeping the pan off. Coal is very fine and wet. The stoker stalls are causing serious fluctuations and erratic control of related systems.
86/01/08,09	FBB-1	Stoker unserviceable. Boiler off line. Soupy coal.
86/01/11,12,13 21,22,24	FBB-1	Continuing stoker stall problems.
86/02/08,09,11	FBB-1	Continuing stoker stall problems.
86/02/19,20	FBB-2	Stoker stalls are frequent.
86/03/18-20	FBB-1	Poor coal. Frequent stoker stalls.
86/04/01,05,06 17,21	FBB-2	Coal like asphalt. Frequent stoker stalls.
86/04/24	FBB-1	Frequent stoker stalls. The coal brought in from the stockpile should have been left there.

It is not difficult to deduce from the log record that the stokers are ill-designed to handle the coal which they often receive. In fact the whole of the coal handling and transport system, in particular the bucket elevators and conveyors, are subject to frequent failure because they are not designed to handle the coal they receive.

It is EMR's opinion that DND are purchasing, and being supplied, design coal. It is considered that open stockpiling and the size degradation that results from stockpiling are the root causes of the high moisture and fines that result in in-plant handling problems. Consequently, the coal procurement procedure has been changed. Beginning with the 1985/86 heating season, coal is supplied on an as-required basis, and delivered by truck directly to the storage silos. This has substantially alleviated the problem; the foregoing record of stoker stalls correlates fairly well to periods when coal was drawn from the stockpile, either because delivery was interrupted by weather, or bacause efforts were being made to clean up the stockpile.

411.3 Furnace Components

Three furnace components are discussed in this section:

- Interbed Transfer Gate
- Distributor Plate and Nozzles
- Thermocouples

411.31 Interbed Transfer Gate

The interbed transfer gate was designed to permit bed material to flow from bed "A" to bed "B", as the means for lighting-up bed "B", which is not equipped with an ignitor. Photographs 36 and 37, in Part 5 of this report, show the gate as originally designed. It is also shown sketched in cross-section in Figure 4-2. It was designed to be kept closed except during the process of lighting-up bed "B". The gate consists of a steel rectangular plate placed vertically with its lower edge sliding in a horizontal track. Its upper edge travels in a horizontal channel which is fixed to the membrane partition wall. The sliding gate was driven by a pneumatically-actuated shaft extending through the stoker wall of the secondary bed. Being uncooled, the steel plate and shaft soon warped and jammed. Also, the water tubes in the partition wall could not be protected against erosion in the areas where the gate moved against the partition wall. The bed transfer gate malfunctioned from the very beginning, and no permanent repair could be effected. It would not shut when open; it would not open when closed; and much of the time it just stuck in a half-open position.

The following extract from a paper by V.V. Razbin and F. Friedrich presented in April 1986 at an EPRI seminar on "AFB Technology for Utility Application", held in Palo Alto, describes the modifications made to correct the problem:

"At times when the gate could not be closed, it was observed that with Bed A in operation and Bed B slumped, the opening sealed itself with a build-up of slumped material in Bed B. It was therefore decided to remove the gate and leave a smaller, permanent opening. This was accomplished by welding in a steel plate and protecting it with refractory on both sides, as shown in Figure 4-2. Also, studs were applied to the previously unprotected membrane wall tubes.

Some experimentation was required to establish an optimum size for the opening (see Photographs 38 and 39 in Part 5). Occasionally crusting of the slumped material occurred, and prevented a free transfer of material when bed "B" was subsequently fluidized. This was overcome by installing two compressed air jets in the opening, pointing from bed "A" to bed "B".

The permanent opening has permitted trouble-free operation throughout the 1985/86 heating season. Bed "B" can be slumped at a low level while bed "A" is operating at normal level. Ignition of bed "B" is accomplished quickly and reliably when it is fluidized. The air jets were used only on a few occasions when the difference in height between the two beds was insufficient to cause the desired flow from bed "A" to bed "B".

One minor disadvantage of the permanent opening is that the two beds cannot be in operation at different levels."

411.32 Distributor Plate and Nozzles

The distributor plate (also called grid plate) forms the bottom of the fluidized bed furnace, and is located above the plenum to which the FD fan supplies fluidizing air. See Figure 3-2. The air flows upward through nozzles, also called bubble caps, located in the distributor plate, which is so named because it distributes air uniformly for fluidizing the bed and maintaining its fluid condition.

To prevent bed material from seeping through the nozzles into the windbox, the nozzles are tee-shaped, as shown in Photograph 42 in Part 5. Air from the plenum below the plate flows up through the nozzles and enters the fluidized bed as horizontal jets a few inches above the distributor plate. In normal operation the space between the plate and the jets is filled with slumped bed material. This material, together with heavier ash particles descending through the bed, is stirred up and entrained by the air jets, forming abrasive streams which wear away the surfaces on which they impinge. It will be seen from Photographs 24, 35 and 42 that care is taken to angle the T-shaped nozzles in such a manner that their air jets do not directly impinge on contiguous surfaces. Photograph 44 illustrates the erosive consequence of direct impingement at close range.

From the above description it is obvious that the distributor plate and the nozzles compose a single functional entity and must be discussed together.

The problems experienced with the distributor plate and nozzles are classified broadly as follows, and are discussed below in this order:

- Leakage from the peripheral furnace seal at grid plate level around each bed.
- Fluidizing of Bed "A"
- Erosion caused by air entrained particle impingement
- Mechanical problems.

PERIPHERAL LEAKAGE

Peripheral leakage from the beds at the level of the distributor plate was one of the earliest problems encountered on start-up in December 1982. Attempts to ignite and operate FBB-1/A on 5 and 6 December and again on 12 and 13 December 1982 were frustrated by leakage. The plant logs for those days contain the following records:

FBB-1:

82/12/05

Limestone was fed to A bed and airflow gradually increased to fluidize the bed. Air and limestone were found to be leaking through gaps in the grid plate to jacking channel seal. Fifty percent of the seal was found to have gaps ranging from 3 mm to 4.5 mm.

82/12/06

The gaps were sealed with fiber rope and silicone caulking.

82/12/13

Discovered a limestone leak in the grid seal working its way out of the left and right side walls. The sections of insulation and lagging were removed and "Nuvaseal" applied to seal the leak. This did not solve the problem.

82/12/14

The limestone leak had increased to an unacceptable level. It was discovered that the leak is occurring through the seal material at the jacking angle, fin bar and scallop bar. The use of a mouldable fibrefrax and light gauge stainless steel flashing was approved for installation. This was to be weld sealed.

FBB-2:

82/12/16

Sealed joints in plenum chambers in FBB-2 with silicone caulking.

83/01/04

Installed Fiberfrax in "A" bed and fitted cover plates for grid plate seal.

83/01/12

Welded grid plate seals in "A" bed. Installing moldable fiberfrax in "B" bed grid plate seals.

83/01/13 & 14

Seal welded grid plate seal plates in "A" and "B" beds and completed installing fiberfrax.

These repairs in FBB-1 and FBB-2 had to be checked and reinforced again in May 1983, when the plant logs show a recurrence of the problem:

FBB-1:

83/05/01

Bed material leaking through casing at right hand side of FBB-1, coming from the A bed grid plate seals. The lower cladding and insulation in this area was removed and it was discovered that considerable air and bed material was leaking through the space between plenum chambers.

By 19:00 hours the leak had become serious, and was not accessible. Bed material including glowing embers was being blown out 2 meters from the side of the unit.

The unit was shut down at 20:00 hours.

83/05/02

Entered "A" bed and cut open grid plate seal cover plate. Fiberfrax seal was worn out in an area where there is a 1/4" wide gap in the original seal, about 3" long.

The cover plates were warped and had lifted up from the grid plate but this warpage probably occurred after the leak had started and hot material was flowing behind the plate.

Thorough repairs were carried out in May 1983 on both boilers and the seals were heavily reinforced with an appliction of high temperature silicone caulk.

However, on 17 and 20 February 1984, some small leaks were discovered in FBB-1/B and were seal welded.

In April 1984 bed material was found to be leaking into the plenum chamber of FBB-1. The boiler was shut down for repair.

During the summer shutdown in 1984 plenum seal angles were installed in both FBB-1 and FBB-2.

FLUIDIZING OF BEDS "A" AND "B"

As originally designed and built, the boilers had 70% more nozzles in Bed "B" (4.5 ft x 9.5 ft = 42.75 sq.ft. i.e. 1.37 m x 2.9 m) than in Bed "A" (4 ft x 9.5 ft = 38 sq.ft. i.e. 1.22 m x 2.9 m) while the difference in area was 12.5%. This resulted in start-up difficulties, even when reinjection air was used to help fluidize Bed "A", a procedure which had its own problems, as already described in Part 411.1. If reinjection air were not used, even a thin bed of double screened limestone could not be readily fluidized. As this material was gradually heated up, using the ignitor, some coal was periodically added for surface burn, thus increasing the surface temperature. Air flow increase then resulted in movement on the surface of the bed. By this staged procedure for achieving fluidization, the bed temperature was gradually increased until all the bed was fluidized and all temperatures equalized. However, the process proved hazardous for the thermocouples, which were exposed to high surface burn temperatures. In consequence, thermocouple failure was frequent and on the surface of the bed weak clinkers commonly formed which broke up once full fluidization was achieved.

Bed "B" experienced no fluidization problems and was very easy to light-up. During the summer of 1984 a total of thirty (30) extra nozzles were added to bed "A" and to bed "B" of each boiler. The peripheral nozzles earlier installed on a trial basis to counter the downward erosive action of the bed (see 312.4) were extended by 7-1/2 in. In addition to this, six (6) nozzles, using straight 1-1/4 in. pipe were installed in bed "B" along the front wall, next to the in-bed tubes.

In the summer of 1985 the number of nozzles in bed "A" of each boiler was increased by 75%. All six (6) 1-1/4 in. nozzles were removed.

As a result of these measures Bed "A" now fluidizes readily on start-up.

Quoting again from the paper by V.V. Razbin and F. Friedrich presented in April 1986 at an EPRI seminar on "AFB Technology for Utility Application", held in Palo Alto:

"The reduced pressure drop across the distributor plate of Bed A has made it possible to fluidize a cold slumped bed 610 mm (24 in.) in depth. Boiler start-up is easier, more reliable, and quicker (typically 30 min. from the first introduction of coal to the full capacity of Bed A). More important, it is now possible to use a less-expensive, single-screened limestone, 6 mm (1/4 in.) x 0 in size, instead of double-screened limestone."

EROSION

Erosion of boiler tubes as a result of bed turbulence has been dealt with in Part 3 of this report. This section of the report will confine itself to discussing the localized action of particle entrainment in the air jets from distributor plate nozzles.

Photograph 42 shows the T-head nozzles which are bolted to the distributor plate. The horizontal air jets emerging from the two nozzle openings on opposite sides of the T-head entrain bed particles which are in their path along with others which are sucked into the jetstreams. Since these jets are located in the lowest section of the bed, which contains the heaviest particles, the entrained particles acquire a considerable momentum and are at temperatures of around 700°C to 850°C at the time they are entrained. Although strike velocity and temperature vary, they are both sufficiently high so that, over a period of time, they will erode contiguous surfaces which encounter direct impingement.

A few examples of erosion caused by particle impingement in the lower portion of the fluidized bed are given below:

- Thermowells which are located directly, and close enough, in the path of a hot particle stream.
- Membrane walls along the periphery of the bed which encounter hot particle streams.
- Seal angle and distributor plate junctions.
- The distributor plate itself was eroded on one occasion when air leaked from the windbox through an opening in the hatch of the distributor plate. This air stream entrained ash particles on top of the plate and directed them at the plate. Photographs 42 and 43 show the consequences of this problem.
- Where a nozzle itself happens to be located in the path of jet-entrained particles it is subject to wear. See Photograph 44 (Note: the term "Bubble Cap" is synonymous with "nozzle").

Long term solutions to some of these erosion problems were not put into effect until the summer of 1985. In most cases patches or other forms of reinforcement were applied as temporary measures until the dimensions of the whole distributor-plate-nozzle problem could be gauged and an overall solution worked out. Finally, the following measures have been put into effect, and it is expected that these problems have, in the main, now been overcome:

- All nozzles have been so oriented that particles entrained in their jets do not directly impinge on contiguous surfaces.

- Where such orientation is not possible, as in the case of peripheral nozzles, the openings facing the membrane walls have been closed.

- All thermowell piping has been reinforced at its lower end as shown in Figure 4-3.

MECHANICAL PROBLEMS

The only mechanical problem that was encountered with the distributor plate and nozzles was the loosening up of the nozzles at their bolted junctions with the distributor plate. See Photograph 42. It was found that the bolting proved inadequate, and finally all nozzles have been welded in place.

411.33 Thermocouples and Thermowells

These components suffered from problems of bed malfunction, mainly high surface temperatures at low bed levels and erosion caused by entrained particle impingement.

The problems of fluidizing bed "A" on start-up have been described in Part 411.32. The difficulty of fluidizing the bed resulted in high surface burn and low bed level which, along with the heat contributed by the ignition burner, combined to raise the temperature enough to melt the tops of the thermocouples. Thus, thermocouple failure was a frequent occurrence until the summer of 1985. The changes effected in the distributor plate and nozzles at that time, as described in the previous section, appear to have solved the problem. In addition, as shown in Figure 4-3, a small hole was drilled in the thermowell, near the upper thermocouple, so that air from the plenum could ventilate the well.

The thermowells have suffered from the same mechanical problems as the nozzles in that their bolting to the distributor plate proved inadequate. All thermowells have, therefore, now been welded to the distributor plate.

To reduce the erosion of thermowells by air jets from nozzles, the wells have been reinforced with steel sleevings at their bases, as shown in Figure 4-3.

It is expected that these combined measures will have successfully solved all the problems causing loss of thermocouples and thermowells. It is heartening to report that there has been no loss of thermocouples in the 1985-86 heating season.

411.4 Boiler and Fluidized Bed

The main problem areas relating to the operation of the fluidized bed boilers have been discussed in Parts 411.1 to 411.3, and the major problem of erosion has been discussed in Part 3. The boilers themselves have performed to specification in terms of their steaming capacity, emissions and efficiency, both on coal and wood firing.

Part 2.2 contains a description of the FBB plant and the contractual specifications for boiler performance. The Eastern Canadian coals tested in these AFBC units ranged in ash and sulphur contents to 25% and 12% respectively, and the units performed to specification with these fuels. More notably, on one occasion coal in the bunkers caught fire, was dowsed to quench and then fed sopping wet into the fluidized bed combustors. The units handled this fuel also despite its high fines and moisture contents. However, the FBB plant is not designed to handle such material on a regular basis. Apart from the danger of clinker formation, which leads to bed drain problems, high-moisture laden flue gases can have medium and long-term consequences for the baghouse filters, particularly if boiler upsets cause frequent start-up and shutdown or if the baghouse hatches are opened during shutdown and moisture is allowed to react with CaO at ambient temperature.

It is appropriate to discuss one particular aspect of fluidized bed boiler operation under this heading, rather than elsewhere, and that is the problem of clinker formation in the fluidized bed. While there is no doubt that the low grade coals fired in this plant, due to their low ash softening temperatures, are more susceptible to clinker formation than better grade fuels, the problem can be reduced to a minor infrequent nuisance by good bed design and operation. The key element in the prevention of clinkers is the avoidance of localized reducing conditions in the combustor. This requires a uniform fuel distribution by the stokers, and judicious control of air flow by the operators, particularly during start-up or refluidizing of a slumped bed, when, to raise bed temperature, coal is fed under minimum air flow conditions. While moisture in the fuel does not directly cause clinker formation, it does lump the fuel, impairing stoker performance and adversely affecting even fuel distribution in the bed. This contributes to conditions which favour clinker formation, particularly during cold or slumped start-ups. As the operating staff have gained experience through trial and error, the frequency and severity of clinkering has been reduced.

This improvement would not have been achieved without progress in distributor-plate-nozzle system design along with the modifications made to the ash reinjection system design.

Bed drain malfunction has also been reduced as clinker formation has reduced.

412 ASH SYSTEMS

As described in Parts 223.4, 226.5 and 226.6, there are two ash collection systems and a common ash handling system.

Boiler (bottom) ash is collected by a bed drain system, and fly ash is collected by bag filters located in a baghouse downstream of the economizer.

A pneumatic ash handling system collects both bottom ash from the bed drains and fly ash from the baghouse hoppers.

Parts 412.1 and 412.2 evaluate the operation of these systems of the FBB plant during the period December 1982 to June 1986.

412.1 Boiler Ash

Boiler ash consists of the bed residuals, which include both fuel ash and spent limestone along with incombustibles such as stones, slate and other entrained impurities. The bed drains may be operated automatically or manually, and their operation is based on bed level control. In the automatic mode the boiler control system, sensing bed level, holds the d.c. motor drive to a speed which extracts bed residue at a rate sufficient for maintaining a specified bed level.

The problems encountered with bed drains operation are broadly classified as follows:

- Speed and level control
- Fouling by clinkers and other foreign objects

- Mechanical problems

- Coolant leakage

An evaluation of each of these classes of problems is given below:

CONTROL PROBLEMS

Two control problems were encountered, one being a speed and capacity control problem, and the other a level control problem in the bed drain cooler.

As originally designed the auger speed was to be so controlled that the bed drain would extract ash at a rate which would hold a specified bed level. Auger capacity is larger than is needed for normal steady state operation when dealing with material density at 50 lb/cu.ft. (800 kg/m^3). In practice boiler ash density was found to be about 60% greater than design density. For these reasons, when operating in the automatic mode, the control system slowed down the variable speed drive to about 20 auger rpm in order to hold a steady bed level. At this slow auger speed the system operated on low torque, with the result that the twin-screws were unable to force even small stones or clinkers or other foreign objects through without overheating and stalling the drive motor. This situation was aggravated by mechanical problems, such as bending of auger shafts and breaking of shear pins as described below under "Mechanical Problems".

The controls were, therefore, modified, so that the screws would run intermittently. The motor did not start until pressure drop across the bed increased to 20 mm H_2O above the set point of 600 mm H_2O. Then the drain operated at a 100% speed, with adequate torque, until the pressure drop across the bed dropped to 20 mm H_2O below set point. This system was found more satisfactory than the variable speed control system, but was later abandoned because of controls malfunction. During the 1985-86 heating season, bed material removal was on manual control with set point at 400 mm H_2O pressure drop across the bed.

FOULING

Fouling of the bed drain system due to clinker formation in the bed and its entry into, and jamming in, the drain, was a recurring problem in the first two years of FBB operation. After the distributor-plate-nozzle system design improvements were effected the fluidized bed operation has been improved to the point where clinker formation has been greatly reduced in both frequency and severity.

Fouling by other foreign objects, such as stones and pieces of steel is also now less frequent.

MECHANICAL PROBLEMS

The bed drain system encountered several mechanical problems, as described below:

Shear Pin Breakage

According to plant logs, shear pin breakage was fairly frequent during early operation, and still occurs infrequently. The cause is insufficiently sturdy construction of the bed drain coolers.

Bending of Augers

With a 7 in. diameter and a 14 ft. span, the augers proved insufficiently robust for the application. Because of the flexibility of the augers, rocks and heavy clinker formations forced the centre of the auger flights to bend and jam against each other or against the upper brace. It is recorded that the flights of the screw were ground once to provide additional clearance. On one occasion the auger was removed, straightened and replaced. The upper brace has now been entirely removed.

Malfunction of Bed Drain Hopper Valve

This appears to be an incurable problem. It either will not open or will stick in an open position. Plant logs record continuation of this problem right through into 1986. On a trial basis a more powerful pneumatic cylinder has been installed on the FBB-1/A ash bin valve.

Breakage of Bearing Housing

There is one report of a bearing housing at the motor end being broken. Repair was effected and there was no repetition of the problem.

Choking Up at the Start of the Auger

An additional problem was caused by boiler ash piling up at the bottom end of the bed drain downcomer and choking up the start of the auger, so that material would not flow along the auger. This problem was solved by welding a constriction at the lower end of the downcomer pipe in order to regulate and reduce the surge of ash into the auger entry.

COOLANT LEAKAGE

While this has not been a serious problem, having water dripping from every seal at the ends of the shafts has not contributed to good housekeeping. There is one report of serious coolant system leakage at the drain pipe outlet of one of the augers. This was weld repaired. On another occasion a burst hose was replaced.

412.2 Fly Ash

The baghouse was initially constructed with a reverse air filter cleaning system, but this was replaced with a pulsed air cleaning system prior to commissioning of each boiler. The change was based on experience at Foster Wheeler's fluidized bed boiler plants in Kentucky, U.S.A. and at the Shell refineries in Holland.

For testing and initial operation of FBB-1/A in December 1982 and up to 20 January 1983, the baghouse was bypassed until the retrofit was completed on FBB-1. The retrofit to a pulsed air system on FBB-2 was completed in early March 1983, and first operation of the FBB-2 baghouse took place on 10 March 1983.

The problems encountered with the fly ash system may be broadly classified as follows:

- Faulty retrofit prior to start-up.
- Ash build-up on hopper level probes.
- High loading, mechanical failure and bag ruptures.
- Intermittent operation, along with moisture in pulsed air and wet or high-clay coal.

Each of these problems is discussed below in the order of the listing.

FAULTY RETROFIT PRIOR TO START-UP

The retrofit of the baghouse from a reverse air to a pulsed air cleaning system appears to have been rushed in order to get the baghouse in operation as quickly as possible, so that the flue gas system would not run too long on bypass. In April 1983, just after FBB-2 baghouse was put into service, it was discovered that one of the bags was missing. It was assumed that it was not installed properly (or at all?). A similar fault was discovered in FBB-1, also in April 1983, except that the errant bag was discovered fallen in the hopper discharge valve. As in the other case, several bags had to be changed when the problem was corrected.

ASH BUILD-UP ON HOPPER LEVEL PROBES

Material build-up on the baghouse hopper level probes prevented correct probe function so that hopper discharge malfunctioned. Purge air was therefore provided to keep all hopper level probes clear of material build-up.

HIGH LOADING, MECHANICAL FAILURE AND BAG RUPTURES

Some of the major problems encountered by the baghouse were caused by malfunction in other plant systems. One such source of trouble was operation of the FBBs at high excess air after the application of Lavalox to the waterwalls. The refractory applied to the waterwalls within the fluidized bed zone reduced the heat exchange surface, which in turn required the boilers to be operated at higher excess air levels in order to control bed temperature. This resulted in greater elutriation from the bed. The higher than expected carry-over resulted in high loading on the baghouse. In addition to this, a mechanical valve failure in the Permalok vent system permitted coarse material to bypass the reinjection system and flow directly to the breaching upstream of the baghouse. Once in the baghouse, these coarse particles abraded the lower sections of the bags, causing ruptures which allowed ash to be sucked into, and erode, the ID fan. A great deal of the coarse material settled in a heap at the base of the stack and lay there until discovered and cleared out.

The ID fan was so badly damaged during the 1984-85 heating season that it had to be replaced.

Another mechanical problem was excessive wear on the venturi elements located at the top of each bag. The wear pattern indicated that high moisture in the pulsed air jets was the cause.

INTERMITTENT OPERATION, ALONG WITH MOISTURE IN PULSED AIR AND WET OR HIGH-CLAY COAL

Due to intermittent operation caused by frequent boiler upsets, moisture and high ash content in the fuel, along with moisture in the pulsed air cleaning system were persistent causes of clogging and poor filter performance. They are most likely to have contributed to bag breakdowns. These problems, combined with recurrent boiler fluctuations resulting from bed instability, ash reinjection system pulsing, clinker formation and such other causes of instability, greatly reduced bag life. The plant logs record that lumps were actually formed within the filter bags. Some of these occurrences appear to be related to occasions when, on start-up, the baghouse was bypassed, and then the bypass was closed and the baghouse was brought into service while flue gas temperature was still too low for optimum baghouse operation. A further cause of trouble arose from the access ports (hatches) of the baghouse hoppers being left open during the summer shutdowns. The calcium oxide in the ash absorbed moisture from the air at ambient temperature and cemented in the bags.

SOLUTIONS TO FLY ASH SYSTEM PROBLEMS

The problems with the fly ash system appear to have been reduced as a result of modifications which have been made to other FBB plant systems, such as the following:

- The fluidized bed systems, including the distributor plate, nozzles, studding on membrane walls, rodding on in-bed tubes and bed perimeter sealing.

- The ash reinjection systems.

The improvements achieved in these systems have resulted in more stable boiler operating conditions. Also, the leakage of coarse particles from the ash reinjection system has been stopped. These improvements should have a significant impact on baghouse operation and filter life.

However, baghouse problems have not yet been solved because the fluidized beds are operating at higher than design excess air. This leads to higher fly ash loading in the flue gas and greater than design gas volumes. The air to cloth ratio is in the range of 4.5 to 5.0, whereas the industry standard is in the range of 3.0 to 3.5. The plant has now purchased longer bags to increase surface area and thus reduce the air to cloth ratio, but these have yet to be installed.

412.3 Ash Handling System

This system, as described in Part 223.4, collects and pneumatically transports both boiler residue and fly ash to an ash silo which has a 68 hour storage capacity. The silo discharges ash to trucks which haul it to the dump site.

While the pneumatic system for collection and transport of boiler and fly ash experienced no problems, the ash silo did. Being outdoors and uninsulated the silo condensed moisture which mixed with the ash and caked it. The ash discharge gate under the ash separators was subject to mechanical malfunction. It would not open, would not close or would stick half-way. Finally it is reported to have fallen into the ash silo.

The silo has now been insulated, which has cured the problem of condensation, and the silo discharge gate has been repaired.

413 DRAFT SYSTEM

The draft system is the largest single consumer of electrical power in the FBB plant. It has been designed to cope with the severest possible plant operating conditions, and has been able to do so. It is also now the major contributor to plant noise. Prior to modification of the ash reinjection system, the positive displacement blowers of that system were the worst offenders in terms of plant noise.

The draft system on its own account did not encounter major problems. The ID fan of one boiler was badly damaged and had to be replaced, due to a problem in the ash system, and this has been discussed in Part 412.2 above. In addition, the inlet damper to the ID fan for one boiler required extensive efforts to resolve a jamming problem.

The FD fan inlet has now been raised to steam drum level, without removing the original inlet silencer, and the intake has been turned down to an angle of 45° to plumb, by turning it through 135°. This allows warm air to enter the plenum chamber and further help fluidization under cold conditions.

In the early stages of plant operation some work was done to seal all the joints in the plenum to prevent leakage of air and bed residue, but this was not a major or persistent problem.

There was also some early concern about air flow measurement to individual beds since the venturis were located close to a bend in the ducting and also close to dampers. It was suspected that turbulence at these points may give incorrect air flow readings. To this date the air flows to bed "A" and "B" cannot be measured accurately.

The plant logs record that at one time considerable bed residue was discovered heaped up in the plenum. This was either due to peripheral leakage or due to leakage of bed material from openings left by broken thermowells. The involvement of the draft system in this was purely incidental.

Except for these minor problems the draft system has performed satisfactorily. The noise and high power consumption, though, continue to be sources of concern.

4.2 COMMON SYSTEMS

421 FUEL AND FUEL HANDLING SYSTEM

421.1 Coal Sources and Characteristics

During the period December 1982 to June 1986 there have been only two sources of coal supply to the FBB plant:

- Evans Coal Mines Limited
  No. 5 Seam
  St. Rose Coal Basin

- T. Brogan & Son Construction Limited
  Upper & Lower Bonnar Seams
  Point Aconi, Cape Breton, N. Scotia

Enclosed in Appendix I are copies of the specifications of the Standing Offers and the "As Received" analysis of sampled coal from these sources.

While FBB plant logs record recurring complaints by plant operating staff of high moisture and high clay or slate inclusion and fines in the coal as received by the boilers, there is no doubt that the coal supplied appears to have consistently met design coal specifications.

421.2 Plant Coal Handling Systems

The standard procedure, up to the 1984-85 heating season, for coal receiving, handling and storage at the plant is described below.

Coal is delivered by truck and dumped on open yard at site. It is pushed by front-end loader or bulldozer into the main coal pile. This process crushes the coal and increases the proportion of fines.

Since the heating season starts in October of each year, coal deliveries commence in August or September. Very often the coal starts fires by self-ignition in the piles. In such cases it is moved around into sub-piles and the burning coal segregated and possibly dowsed. This movement creates more fines. If there has been rain or snow, the process of moving the coal around also results in increasing its moisture content. Clay inclusion in batches of coal may also result from this process.

When this coal is delivered to the plant coal handling and transport systems and to its storage bunkers, it clogs up almost all parts of the system. Plant logs indicate that when fresh deliveries of coal directly enter the plant system, they go through them quite well.

Since the beginning of the 1985-86 heating season coal has been delivered directly through the plant receiving systems into the plant storage bunkers. Because truckers have less employment during winter months, covered trucking of coal for this purpose on a scheduled basis is possible. A covered emergency stockpile can also be held in reserve. A once a week delivery of coal can be organized through the winter months and varied at short notice to suit plant operating demand.

The problems encountered by the stokers have already been related earlier in Part 411.2. All the system components upstream of the stokers (shown in the flow diagram of Figure 2-3) were casualties of the same basic problem. The plant logs indicate that the system had ceaseless problems with plugging and clogging of wet fines in every component of the system.

The following extracts from plant logs indicate the magnitude of the problem:

<ins>84/01/12</ins>

Duncan Thompson of Sullivan, Strong, Scott (SSS) at site. Walked down coal handling system and pointed out problem areas.

He did have one recommendation to make and that was to change the sprockets on the operator from a 1 to 4 ratio to a 4 to 1 ratio.

As a consequence of this visit the following letter was received by FWL from SSS:

Gentlemen:

The following points were stated and discussed in our meeting of January 4, 1984:

General:

1. The overall plant has been in operation for approximately 600 to 800 hours, however, is presently shutdown until month end.

2. The Limestone Handling System is functioning without any problem.

3. The Wood Handling System has not yet been implemented.

Problems associated with the Coal Handling System:

1. The coal properties are other than originally expected in the specification, i.e.:

a) Contains a surplus of fines (only 5% of the coal reaches the crusher)
b) Wetness
c) Extremely fragile

2. When the coal is dry or very wet, the material is conveyed without difficulty.

3. The screened fines collecting hopper plugs as frequently as every 20 minutes under certain coal conditions.

4. Evidence shows cracks as long as 8" in the screen body. (FWL to advise exact location of damage.)

5. Slide gates between the "En-Masse" Drag Conveyor and the bunkers are jamming, causing difficulty for manual operation.

6. Vibrating bin dischargers are not performing as expected under certain coal conditions.

7. Bucket elevator boot sections fed by screw conveyors from bunker are continuously plugging.

8. The same elevator's buckets are not discharging properly as material is sticking badly.

9. Flop gates fed by the same buckets are jamming and have to be cleaned frequently.

General ideas to alleviate situation were discussed such as:

- use of dryers (Air, Heating Element, etc.)

- vibrators
- change the state of coal

FWL requested SSS representatives prior to and following next start-up. FWL also urged SSS to react prior to month end.

Following this meeting SSS's territory representative visited the site and reported that coal used is extremely unsuitable for this type of equipment application, and maintenance personnel are experiencing problems throughout the coal system and not only in the above mentioned areas. Sullivan, Strong, Scott also contacted the screen supplier (Dillon) regarding the plugging and failures occurring. They advised us that any repair of cracks in the screen body should have been by bolting (not welding) otherwise progressive cracks will occur.

Sullivan, Strong, Scott Recommendations:

It appears beyond any reasonable doubt that the coal type used is the main problem.

We strongly recommend use of coal similar to that originally specified or changing the condition of coal currently used as was discussed in the meeting.

However, limited improvement could be achieved by using the following on a trial basis:

- Tapco plastic bucket in problem elevator.
- Reverse location of sprockets on slide gates. (Recently advised site maintenance personnel.)
- UHMW (Teflon-like) Liners on flop gates.

Note! All other transfer areas have been re-assessed and we feel it is inadvisable to alter them, as they are lined adequately and designed properly to accommodate specification coal.

Sullivan, Strong, Scott would appreciate obtaining a coal sample currently used with complete analysis for further consideration to the above problems.

84/03/15

Modifications were made to two problem areas in the bunker filling coal handling system.

FBB-2 was shut down during the night due to coal pluggage and stoker problems from trying to move wet coal.

84/03/16

Ran coal through bunker filling system. The modifications eliminate problems in these two areas. However, there are still many problems moving sticky coal elsewhere.

84/03/23

Strengthened the extension piece which has been added to the end of the vibrating feeder.

84/04/16

Base ordered dry coal direct from the mine which flowed through the material handling system with no problems and actually cleared out the buckets and previous buildups.

Changes, improvements, modifications too numerous to list in this report were made to the system over the four heating seasons ending June 1986. For example conveyor chains have been strengthened, stronger buckets have been put into the bucket elevators, cleaning openings have been provided at appropriate points, compressed air jets have been provided at selected points, chute angles and forms have been changed, riders have been installed to hold down the lower drag chains on the drag conveyors, etc. The whole system is now operating better, but is not trouble-free. The lesson, perhaps, is that despite decades of development, an economical, trouble-free system for handling wet, fine coal is still difficult to achieve.

422 LIMESTONE AND LIMESTONE HANDLING SYSTEM

422.1 Limestone Source and Characteristics

The FBB plant had difficulties in bed fluidization with the limestone initially supplied, which was sized at 6 mm (1/4 in.) x 0. Subsequently a limestone double-screened to the specifications provided by FWL was purchased, but this did not substantially alleviate the fluidization problem, which was due to other causes, as already discussed.

Ultimately, however, after the modifications during the summer of 1985, which resolved the fluidization problem, limestone specifications were relaxed and the plant has been purchasing single screened 6 mm (1/4 in.) x 0 limestone for almost half the price of the double screened material.

The following extracts indicate the progress made in clarifying the limestone specification and size requirements:

83/03/09

Review of the various sampling and documentation have shown that the limestone grading should be:

- Maximum of 10% at the #8 sieve.
- Maximum of 10% at the #20 sieve.
- with a graded band for #12 thru #18.

83/11/21

The following is recommended as a general specification for limestone as an SO_2 sorbent.

We have gone back to 8-mesh as the top size because the suppliers Colin contacted couldn't provide a 10-mesh top size, and the boilers seem to be able to fluidize 8-mesh provided oversize is within the specified 10% limit.

Specifications for Limestone to be Used for SO_2 Control in the Fluidized Bed Boilers at CFB Summerside

1. Analysis

The limestone shall contain a minimum of 90 wt % $CaCO_3$, as determined on a moisture-free basis.

2. Moisture Content

The limestone as delivered shall not contain more than 5 wt % moisture. Shipments should be covered with tarpaulins, or otherwise suitably protected, to avoid moisture pickup during transport.

3. Size Consist

The particle size of the limestone, as delivered, shall be 8 x 20 mesh (2.36 mm x 0.85 mm). The fraction retained on an 8-mesh screen (+8 mesh) should be as low as possible, and shall not exceed 10 wt %. The fraction passing a 20-mesh screen (-20 mesh) is less critical but should not be more than 10 wt %.

(Note to DND: The following requirement is an option which you may include at your discretion. There is some difficulty in ensuring a representative sample, except by an ASTM standard sampling method which is inconveniently long and complex.)

The Contractor shall supply a sieve analysis of each delivery. This shall be performed on a grab sample of the material in each delivery (truckload or other container), sieved using an 8-mesh sieve, a 20-mesh sieve, and a pan. The results of the analysis must meet the requirements of the previous paragraph. If they do not, two more samples shall be taken from the delivery and screened. If the averaged results of the three samples fail to meet the size requirements, the shipment must be rejected.

4. SO_2 Capture Performance

The performance of a limestone as a sorbent for SO_2 in a fluidized bed combustor depends upon various physical parameters of the rock such as its crystallinity, pore volume and hardness, which are difficult to quantify. Therefore, the SO_2 capture performance of the tendered limestones will be evaluated by the Canada Centre for Minerals and Energy

Technology (CANMET) in its bench-scale fluidized reactor. This reactor determines the sulphation capacity, that is, the percent conversion of calcium to calcium sulphate, of a limestone by exposing it to synthetic flue gas under conditions simulating a fluidized bed combustor.

Tendered limestones, in the particle size range of 1.00 mm to 0.85 mm will be exposed to synthetic flue gas containing 0.3 vol. % SO_2 at 850°C. The minimum acceptable sulphation capacity as determined by this procedure shall be 25%.

The CANMET reactor will also be used to determine the size degradation of the limestone due to thermal shock and attrition. This is done by measuring the quantity of dust collected by a cyclone during the test. For a tendered limestone to be acceptable, the elutriated dust shall not exceed 10 wt % of the initial limestone charge.

The bidder shall supply for evaluation a minimum of 4 samples of approximately 1 kg each, representative of various locations in the quarry from which he proposes to supply material for this contract. Samples are required for every quarry if more than one is involved.

During the period of the contract the purchaser may elect to take samples of limestone shipments and have them evaluated for SO_2 capture performance by CANMET. These shall have a sulphation capacity of at least 85% of the sulphation capacity of the tender samples. For example, if the tender samples have a sulphation capacity of 30%, subsequent shipment samples shall have a sulphation capacity of at least 25.5%. Consistent failure of shipment samples to meet the above minimum requirement may be cause for termination of the contract.

422.2 Limestone Handling System

In general the limestone handling system operated satisfactorily. Apart from minor problems such as blinding and tearing of screens due to wet limestone, the need for minor crusher adjustments, a feeder hose break, a weigh feeder belt break with consequent bending of a tail pulley shaft, there was little to complain of, except a serious dust problem.

The limestone receiving area was not sealed off from the rest of the FBB plant, consequently during delivery limestone dust permeated the plant, infiltrating electrical and mechanical equipment. This was resolved by sealing off the delivery area, although the plant still suffers from dust emanating from the limestone conveyors which have no dust control system.

423 ELECTRICAL AND CONTROL SYSTEMS

423.1 Auxiliary Power Unit (APU)

As shown in Table 2-6 in Part 2.2 of this report, the APU was specified to handle the load of one FBB plant. Appendix II contains relevant extracts from the bid document, which show that a 500 kW diesel engine was coupled to an oversized generator.

According to the plant log dated 30 November 1982:

> "A starting test on the APU failed. The ID fan started and ran, but when the FD fan was started with the ID fan running, an excitation diode burned out on overload."

The unit was checked out and it was determined that the suppliers had made some simple component errors. The matter was referred to them and they agreed to send out the correctly sized diodes and M.O.V. suppressor. These components arrived on 28 January 1983 and, upon their installation, the APU was able to accept the rated load. It is possible that the rating difference between engine and alternator may have led to the initial error. Changes were also made to the FD stepped voltage starters to reduce start-up current.

However, when the Lavalox refractory was applied to the waterwall tubes, in order to prevent erosion, as described in Part 3 of this report, the excess air requirement rose dramatically. At that time, with the draft system's FD and ID fans drawing higher current, the APU, which was rated to handle all the electrical power demand of one FBB unit, was unable to supply the auxiliary equipment loads, such as the plant coal and limestone handling loads, along with the increased demand of the draft system. Consequently the APU was unable to run one FBB at full load, and the maximum steam generation on emergency power supply was around 16.5 Mg/h (36,000 pph). A larger APU has been installed in late 1986.

423.2 SO_2 and O_2 Analyzers

The SO_2 analyzer malfunction was traced to condensation in the sampling lines, and was set right with heat tracing of the lines. Cleaning and recalibration of the analyzer was also necessary.

In April 1984 the sample probes and sampling lines were cleaned, filters were replaced, and the instrument was put back in service. During 1985-86 heating season a new sample conditioning system was installed.

The O_2 analyzers had to be recalibrated, and their heaters had to be replaced a few times.

423.3 Steam Flow Transmitter

In May 1983 the steam flow transmitters malfunctioned. The problem was traced to leaks in the sensing lines, and was corrected. Since then, however, the transmitters have not been calibrated and as a result there is significant error in steam flow indication.

423.4 Changes to Control Logic

From time to time changes have been made to the control logic, including the furnace draft control loop. FWL had jumpered a number of controls in order to simplify the start-up procedure, and some of them have been removed. However, the documentation available does not indicate clearly what the changes were, the reasons for the changes, when each was made, and what improvement, if any, resulted from the change. One change proposed for the 1986-87 heating season is to have the O_2 trim follow the temperature setting rather than the oxygen setting.

423.5 Dust Problem

The dust problem caused by the limestone handling system has been described in Part 422.2.

Another source of dust was the leakage of coal fines or their deliberate dumping on the floor to facilitate continued boiler operations (see Photograph 45).

Electrical and control equipment, being generally the most sensitive to dust, was the major casualty of this problem. The provincial Electrical Inspector insisted that all the limit switches on the materials handling slide gates be changed to conform to dust-tight classification.

424 BALANCE OF PLANT

424.1 High Noise Level

The FBB plant has suffered from a high noise level. The main sources of noise are listed below, giving noise level readings of each in dBA at 1 meter from the source:

Equipment	dBA Sound Level
Diesel Generator Unit	108
50 HP Rotary Positive Blowers	107
25 HP Rotary Positive Blowers	105
FD Fans	96
Air Compressors	95
ID Fans	90 approximately at 1 metre
Main Control Room	65

Equipment	dBA Sound Level
Motor Control Centre	77
Electrical Room	70
Pulse Clean Baghouse	110
Bearing Noise from Limestone Conveyor	96
Coal and Limestone Screeners	96

The noise level of the blowers was reduced initially by speed reduction, by installing a cover over the blower and subsequently by the elimination of one blower. The FD fan inlet was raised to the steam drum level.

The other sound sources have not been affected by any changes.

424.2 Oil in Deaerator

FWL state that at DCL's request, exhaust from the steam driven auxiliary boiler feed pump, which would normally be discharged to the blowdown tank, was rerouted to the deaerator as a conservation measure (FWL letter to DCL dated 20 September 1983).

During initial operation it was discovered that the deaerator was being contaminated by lubricating oil in the exhaust of the steam driven pump.

An oil separator and drain trap installation upstream of the deaerator did not solve the problem and now the exhaust is vented to the atmosphere. The steam driven pump is rarely used because of steam wastage.

424.3 Damage to Hotwell Lining

During construction heavy equipment was placed and moved about on the concrete floor above the hotwell. It is suspected that this caused damage to the hotwell lining in areas of its roof, resulting in sludge accumulation in the hotwell. The wall and floor lining was, however, intact. The lining was sealed where it had cracks and penetrations.

424.4 Leakage Into Condensate Line

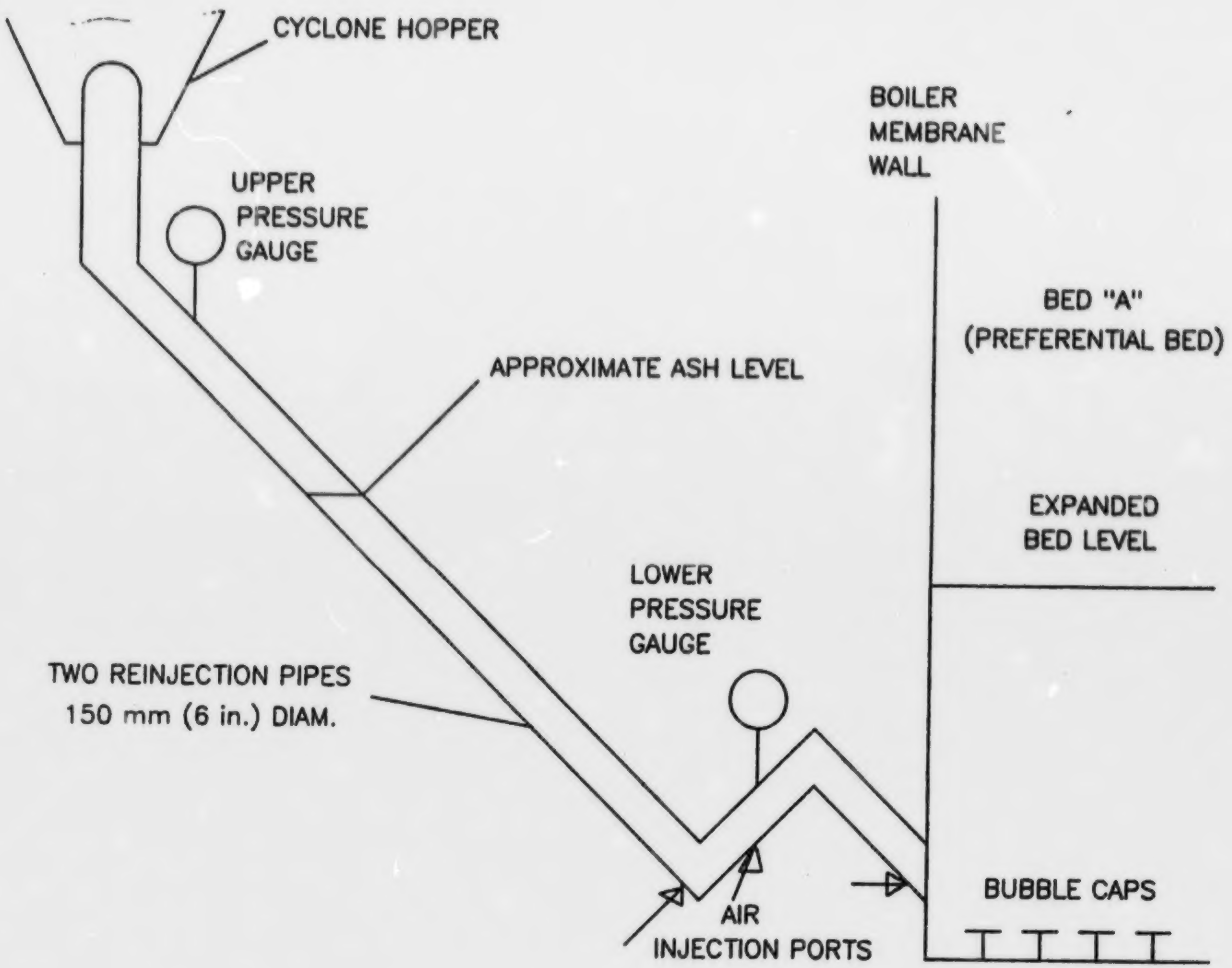
The following entry appears in the plant log:

> 83/02/25
>
> Opened steam and mud drum on #1 unit. There is a coating of calcium on the tubes and drum surfaces much more than should be expected for the length of time the unit has been in operation. The coating had a reddish colour which indicates that there is leakage into the condensate line between #1 heating plant and our hot well.

Following this identification of a potential problem, an investigation into water quality was made, the condensate return lines were checked and repaired and, after an investigation and report by Public Works Canada, additional water treatment equipment was installed to correct the problem.

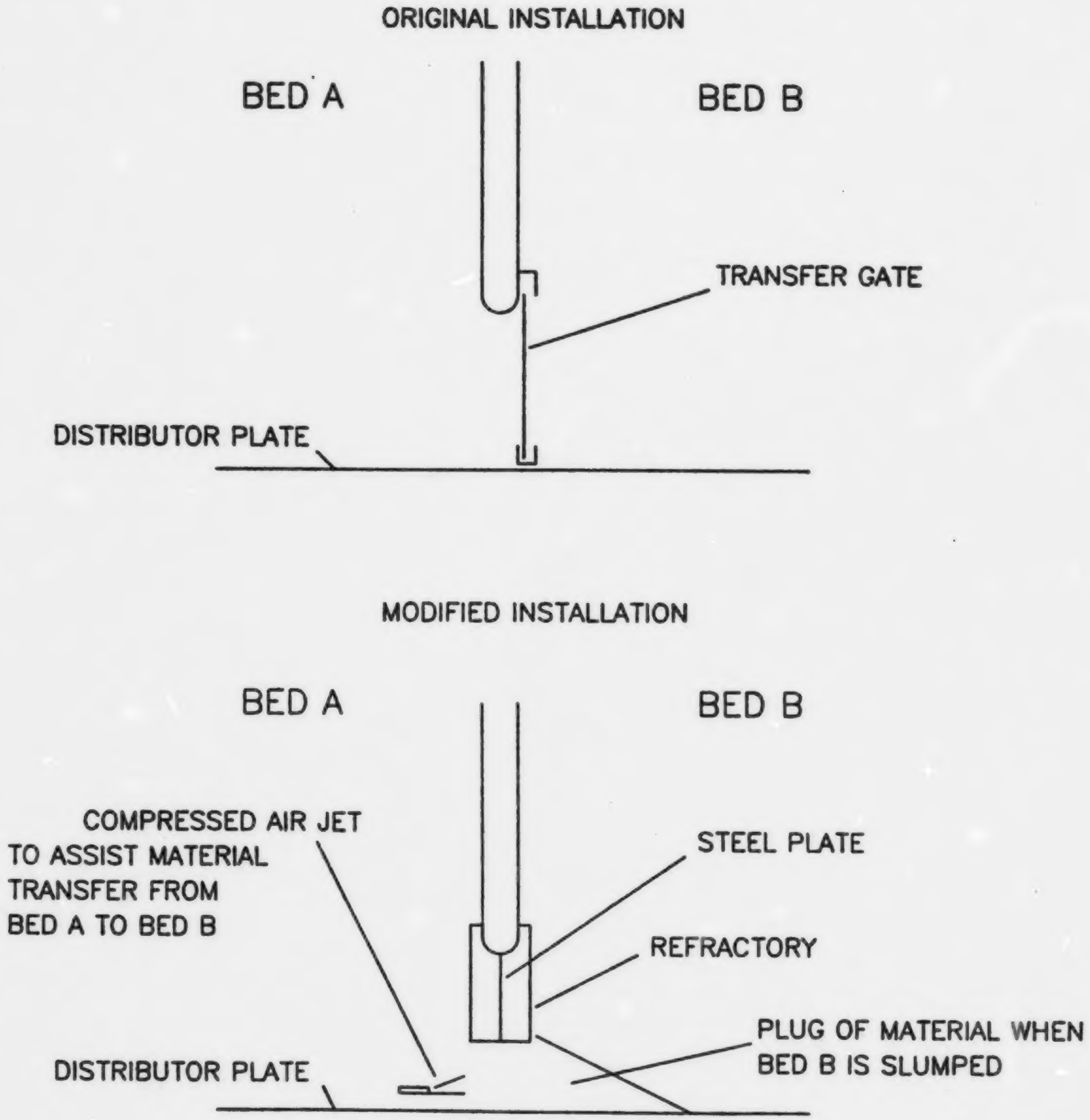
However, as this subject is not directly related to FBC plant design and operation as distinct from conventional boiler plant practice, a detailed evaluation of it is beyond the scope of this report.

Appendix III contains copies of reports by Public Works Canada and Dearborn Chemical Company Limited on the subject.


CYCLONE HOPPER
UPPER PRESSURE GAUGE
BOILER MEMBRANE WALL
BED "A" (PREFERENTIAL BED)
APPROXIMATE ASH LEVEL
EXPANDED BED LEVEL
LOWER PRESSURE GAUGE
TWO REINJECTION PIPES 150 mm (6 in.) DIAM.
BUBBLE CAPS
AIR INJECTION PORTS

Schematic of the new fly ash reinjection system

Figure 4-1
(Courtesy Friedrich/Razbin, EM&R)

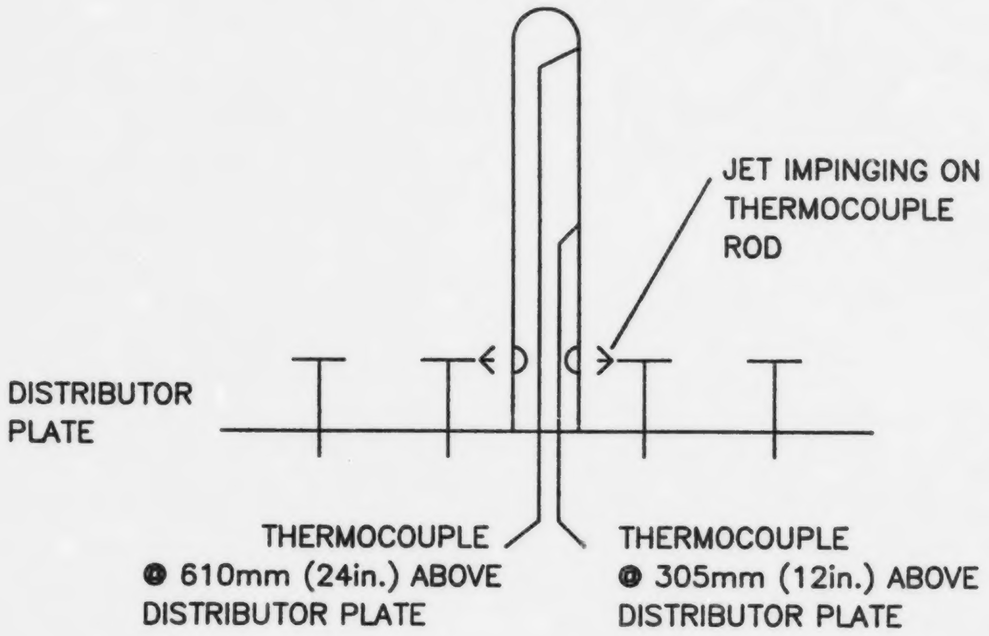

ORIGINAL INSTALLATION
BED A
BED B
TRANSFER GATE
DISTRIBUTOR PLATE
MODIFIED INSTALLATION
BED A
BED B
COMPRESSED AIR JET
TO ASSIST MATERIAL
TRANSFER FROM
BED A TO BED B
STEEL PLATE
REFRACTORY
PLUG OF MATERIAL WHEN
BED B IS SLUMPED
DISTRIBUTOR PLATE

Schematic of the inter-bed transfer gate,as originally installed and as modified

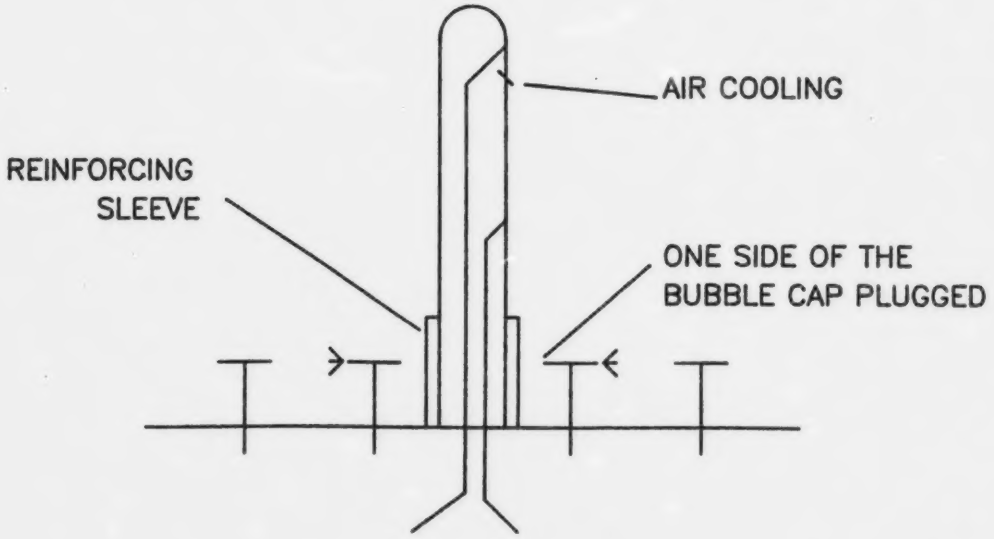
Figure 4-2

(Courtesy Friedrich/Razbin, EM&R)

ORIGINAL THERMOCOUPLE LAYOUT


JET IMPINGING ON
THERMOCOUPLE
ROD
DISTRIBUTOR
PLATE
THERMOCOUPLE
@ 610mm (24in.) ABOVE
DISTRIBUTOR PLATE
THERMOCOUPLE
@ 305mm (12in.) ABOVE
DISTRIBUTOR PLATE

MODIFIED THERMOCOUPLE LAYOUT


AIR COOLING
REINFORCING
SLEEVE
ONE SIDE OF THE
BUBBLE CAP PLUGGED

Bed thermocouple installation as originally provided and as modified

Figure 4-3

(Courtesy Friedrich/Razbin, EM&R)

4.3 DAILY OPERATIONAL RECORD OF FLUDIZED BED BOILERS FBB-1 AND FBB-2

Presented here in tabular form is a daily operational record of FBB-1 and FBB-2 from December 1982 to June 1986.

The central section of the table refers the reader to Part numbers in Part 4, which is 'Plant Operation', thereby indicating which system of the FBB plant had a problem or was under repair or modification on a particular date. This information has been taken directly from Plant logs. It is intended as a record of the frequency with which any particular system encountered problems during the period December 1982 to June 1986.

The table is entirely self-explanatory.

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
82	12	01	Commiss'ing		Nil									
		02	Commiss'ing		Nil				413					
		03	Commiss'ing		Nil							423		
		04	Commiss'ing		Nil				413					
		05	Commiss'ing		Nil		411.32							
		06	Commiss'ing		Nil		411.32	412.2						
		07	Commiss'ing		Nil		411.4	412.1						
		08	Commiss'ing		Nil		411.33/.4		413					
		09	Commiss'ing		Nil									
		10	Commiss'ing		Nil		411.31/.33/.4							
		11	Commiss'ing		Nil		411.33/.4	412.1						
		12	Commiss'ing		Nil		411.4							
		13	Commiss'ing		Nil		411.32/.4							
		14	Commiss'ing		Nil		411.32/.4			421.2		423		
		15	Commiss'ing		Nil		411.32							
		16	Commiss'ing		Nil					421.2				
		17	Commiss'ing		Nil									
		18	Commiss'ing		Nil									
		19	Commiss'ing		Nil		411.4							
		20	Commiss'ing		Nil									
		21	Commiss'ing		Nil									
		22	Commiss'ing		Nil									
		23	Commiss'ing		Nil									
		24	Commiss'ing		Nil									
		25	Commiss'ing		Nil									
		26	Commiss'ing		Nil									
		27	Commiss'ing		Nil									
		28	Commiss'ing		Nil									
		29	Commiss'ing		Nil									
		30	Commiss'ing		Nil									
		31	Commiss'ing		Nil									
83	01	01	Commiss'ing		Nil									
		02	Commiss'ing		Nil									
		03	Commiss'ing		Nil									
		04	Commiss'ing		Nil									
		05	Commiss'ing	A	No Record		411.4							Evans Coal
		06	Commiss'ing	A	No Record		411.4			421.2				Evans Coal
		07	Commiss'ing	A	No Record		411.1/.2		413					Evans Coal
		08	Commiss'ing	A	No Record		411.4	412.1	413	421.2				Evans Coal
		09	Commiss'ing	A&B	No Record		411.1/.31/.4	412.1	413	421.2				Evans Coal
		10	Commiss'ing	A&B	No Record		411.1/.31/.4			421.2				Evans Coal
		11	Commiss'ing	A&B	No Record	Forced	411.4	412.2			422.1/2	423	424	Evans Coal
		12	Commiss'ing		Nil		411.4							
		13	Commiss'ing		Nil		411.31/.33							
		14	Commiss'ing		Nil		411.1/.33		413					
		15	Commiss'ing		Nil		411.33		413					

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
83	01	16	Commiss'ing		Nil				413					
		17	Commiss'ing		Nil				413					
		18	Commiss'ing		Nil		411.4		413					
		19	Commiss'ing	A	No Record		411.4							Evans Coal
		20	Commiss'ing	A	No Record		411.1/.4	412.2						Evans Coal
		21	Commiss'ing	A	No Record									Evans Coal
		22	Commiss'ing	A	No Record		411.4	412.1						Evans Coal
		23	Commiss'ing	A	No Record		411.1							Evans Coal
		24	Commiss'ing	A	No Record		411.1/.4			421.2				Evans Coal
		25	Commiss'ing	A	No Record		411.1/.2			421.2				Evans Coal
		26	Commiss'ing	A	No Record	Forced	411.31	412.1		421.2		423	424	Evans Coal
		27	Commiss'ing		Nil		411.4							
		28	Commiss'ing		Nil							423		
		29	Commiss'ing		Nil									
		30	Commiss'ing		Nil		411.4					423		
		31	Commiss'ing		Nil		411.1/.31						424	
83	02	01	Demonstr'on	A	Nil		411.1/.4							Evans Coal
		02	Demonstr'on	A	156		411.4	412.2		421.2		423		Evans Coal
		03	Demonstr'on	A	149		411.2/.4							Evans Coal
		04	Demonstr'on	A	166		411.2/.4	412.1		422.1/.2		423		Evans Coal
		05	Demonstr'on	A	209		411.1			422.1/.2				Evans Coal
		06	Demonstr'on	A	189		411.1							Evans Coal
		07	Demonstr'on	A	187		411.1/.33/.4		413					Evans Coal
		08	Demonstr'on	A	176	Forced	411.1/.2	412.2						Evans Coal
		09	Modificat'n				411.1/.2/.33/.4	412.2						
		10	Modificat'n				411.1/.32/.33/.4							
		11	Modificat'n				411.32/.33							
		12	Modificat'n				411.1/.32/.33							
		13	Modificat'n				411.4							
		14	Modificat'n								422.1/2			
		15	Modificat'n								422.1/2			
		16	Modificat'n								422.1/2			
		17	Modificat'n					412.1			422.1/2			
		18	Modificat'n								422.1/2			
		19	Modificat'n											
		20	Modificat'n											
		21	Modificat'n											
		22	Modificat'n								422.1/2			
		23	Modificat'n									423		
		24	Modificat'n											
		25	Modificat'n								422.1/2		424	
		26	Modificat'n											
		27	Modificat'n											
		28	Modificat'n											
		29												
		30												
		31												

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
83	03	01	Modificat'n											
		02	Modificat'n											
		03	Modificat'n									423		
		04	Modificat'n											
		05	Modificat'n											
		06	Modificat'n											
		07	Modificat'n											
		08	Modificat'n											
		09	Modificat'n								422.1/2			
		10	Modificat'n											
		11	Modificat'n											
		12	Modificat'n											
		13	Modificat'n											
		14	Modificat'n											
		15	Modificat'n											
		16	Modificat'n											
		17	Modificat'n											
		18	Modificat'n											
		19	Modificat'n											
		20	Modificat'n											
		21	Modificat'n							421.2				
		22	Modificat'n											
		23	Modificat'n											
		24	Modificat'n											
		25	Modificat'n											
		26	Modificat'n											
		27	Modificat'n											
		28	Modificat'n											
		29	Modificat'n											
		30	Modificat'n											
		31	Modificat'n											
83	04	01	Modificat'n											
		02	Modificat'n											
		03	Modificat'n											
		04	Modificat'n											
		05	Modificat'n				411.1							
		06	Modificat'n								422.1/2			
		07	Modificat'n											
		08	Modificat'n									423		
		09	Modificat'n											
		10	Modificat'n											
		11	Modificat'n											
		12	Modificat'n											
		13	Modificat'n											
		14	Modificat'n				411.2							
		15	Modificat'n											

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
83	04	16	Modificat'n											
		17	Modificat'n											
		18	Modificat'n								422.1/2			
		19	Modificat'n				411.4							
		20	Modificat'n				411.2							
		21	Modificat'n					412.2						
		22	Modificat'n											
		23	Modificat'n											
		24	Modificat'n											
		25	Modificat'n											
		26	Modificat'n				411.2	412.1						
		27	Modificat'n				411.2				422.1/2			
		28	Modificat'n				411.4	412.2						
		29	Modificat'n				411.32/.33/.4	412.2						
		30	Modificat'n				411.4							
		31												
83	05	01	Modificat'n				411.32/.4							
		02	Modificat'n				411.32							
		03	Modificat'n											
		04	Modificat'n											
		05	Modificat'n				411.1/.32/.4		413	421.2	422.1/2		424	
		06	Modificat'n				411.32							
		07	Modificat'n				411.32/.33							
		08	Modificat'n				411.32							
		09	Modificat'n											
		10	Modificat'n											
		11	Modificat'n							421				
		12	Modificat'n											
		13	Modificat'n											
		14	Modificat'n											
		15	Modificat'n									423		
		16	Modificat'n							421		423		
		17	Modificat'n											
		18	Modificat'n											
		19	Modificat'n											
		20	Modificat'n											
		21	Modificat'n											
		22	Modificat'n											
		23	Modificat'n											
		24	Modificat'n											
		25	Modificat'n											
		26	Modificat'n							421				
		27	Modificat'n											
		28	Modificat'n											
		29	Modificat'n											
		30	Modificat'n											
		31	Modificat'n											

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
83	10	01	Modificat'n											
		02	Modificat'n											
		03	Modificat'n											
		04	Modificat'n											
		05	Modificat'n											
		06	Modificat'n											
		07	Modificat'n											
		08	Modificat'n											
		09	Modificat'n											
		10	Modificat'n											
		11	Modificat'n											
		12	Modificat'n											
		13	Modificat'n											
		14	Modificat'n									423	424	
		15	Modificat'n											
		16	Modificat'n											
		17	Modificat'n											
		18	Modificat'n								422.1/2			
		19	Modificat'n							421.2	422.1/2		424	
		20	Modificat'n											
		21	Modificat'n										424	
		22	Modificat'n											
		23	Modificat'n											
		24	Modificat'n											
		25	Modificat'n											
		26	Modificat'n										424	
		27	Modificat'n									423		
		28	Modificat'n									423		
		29	Modificat'n									423		
		30	Modificat'n									423		
		31	Modificat'n											
83	11	01	Modificat'n											
		02	Modificat'n											
		03	Modificat'n											
		04	Modificat'n											
		05	Modificat'n											
		06	Modificat'n											
		07	Modificat'n											
		08	Modificat'n											
		09	Modificat'n											
		10	Modificat'n											
		11	Modificat'n											
		12	Modificat'n											
		13	Modificat'n											
		14	Demonstr'n	A	301(*)									Brogans Coal
		15	Demonstr'n	A	293									

*The steam generation figures are for both units.

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
83	11	16	Demonstr'n	A	338									Brogans Coal
		17	Demonstr'n	A	302									Brogans Coal
		18	Demonstr'n	A&B	327									Brogans Coal
		19	Demonstr'n	A&B	334									Brogans Coal
		20	Demonstr'n	A&B	319		411.4	412.2		421.2		423		Brogans Coal
		21	Demonstr'n	A&B	289		411.4				422.1/2			Brogans Coal
		22	Demonstr'n	A	233		411.4	412.1/.2						Brogans Coal
		23	Demonstr'n	A	234		411.1/.4							Brogans Coal
		24	Demonstr'n	A&B	205		411.4							Prince Coal
		25	Demonstr'n	A&B	160		411.1/.4							Prince Coal
		26	Demonstr'n	A&B	201		411.4							Prince Coal
		27	Demonstr'n	A	348		411.1/.4							Prince Coal
		28	Demonstr'n	A&B	387		411.31/.4					423		Brogans Coal
		29	Demonstr'n	A&B	372		411.2/.4					423		Brogans Coal
		30	Demonstr'n	A&B	359		411.2/.4							Brogans Coal
		31												
					7499(*)									
83	12	01	Demonstr'n	A&B	240									Brogans Coal
		02	Demonstr'n	A&B	264		411.31/.4					423		Brogans Coal
		03	Demonstr'n	A&B	321									Brogans Coal
		04	Demonstr'n	A&B	239									Brogans Coal
		05	Demonstr'n	A&B	227									Brogans Coal
		06	Demonstr'n	A&B	336									Brogans Coal
		07	Demonstr'n	A&B	219									Brogans Coal
		08	Demonstr'n	A&B	198		411.4		413			423		Brogans Coal
		09	Demonstr'n	A	210	Forced								Brogans Coal
		10	Modificat'n											
		11	Modificat'n											
		12	Modificat'n											
		13	Modificat'n											
		14	Modificat'n											
		15	Modificat'n											
		16	Modificat'n											
		17	Modificat'n											
		18	Modificat'n											
		19	Modificat'n											
		20	Modificat'n											
		21	Modificat'n											
		22	Modificat'n				411.1/.32/.4					423	424	
		23	Modificat'n											
		24	Modificat'n											
		25	Modificat'n											
		26	Modificat'n											
		27	Modificat'n											
		28	Modificat'n											
		29	Modificat'n											
		30	Modificat'n											
		31	Modificat'n											
					2254									

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
84	01	01	Modificat'n											
		02	Modificat'n											
		03	Modificat'n											
		04	Modificat'n											
		05	Modificat'n										424	
		06	Modificat'n					412.2				423	424	
		07	Modificat'n											
		08	Modificat'n											
		09	Modificat'n										424	
		10	Modificat'n											
		11	Modificat'n											
		12	Modificat'n							421				
		13	Modificat'n											
		14	Modificat'n											
		15	Modificat'n											
		16	Modificat'n											
		17	Modificat'n											
		18	Modificat'n											
		19	Modificat'n											
		20	Modificat'n											
		21	Modificat'n											
		22	Modificat'n											
		23	Modificat'n								422.1/2			
		24	Modificat'n											
		25	Modificat'n											
		26	Modificat'n											
		27	Modificat'n											
		28	Demonstr'n	A	30									Brogans Coal
		29	Demonstr'n	A&B	328									Brogans Coal
		30	Demonstr'n	A&B	343									Brogans Coal
		31	Demonstr'n	A&B	331									Brogans Coal
			Mg/MTH		1032									
84	02	01	Demonstr'n	A&B	252									Brogans Coal
		02	Demonstr'n	A	348									Brogans Coal
		03	Demonstr'n	A	180									Brogans Coal
		04	Demonstr'n	A	171									Brogans Coal
		05	Demonstr'n	A	36	Forced								Brogans Coal
		06	Modificat'n											
		07	Modificat'n											
		08	Modificat'n											
		09	Modificat'n											
		10	Modificat'n											
		11	Modificat'n											
		12	Modificat'n											
		13	Modificat'n											
		14	Modificat'n				411.2							
		15	Modificat'n					412.1					424	

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
84	02	16	Modificat'n											
		17	Modificat'n				411.31/.32/.4							
		18	Modificat'n											
		19	Modificat'n											
		20	Modificat'n				411.32							
		21	Modificat'n											
		22	Modificat'n											
		23	Modificat'n											
		24	Modificat'n											
		25	Modificat'n											
		26	Modificat'n											
		27	Modificat'n										424	
		28	Modificat'n								422.1/2	423	424	
		29	Modificat'n				411.4						424	
		30												
		31												
			Mg/MTH		987									
84	03	01	Modificat'n				411.4						424	
		02	Modificat'n				411.4						424	
		03	Modificat'n											
		04	Modificat'n											
		05	Modificat'n				411.2/.33/.4					423		
		06	Generation	A	45		411.4	412.1		421.2				Brogans Coal
		07	Generation	A	160		411.4					423		Brogans Coal
		08	Generation	A	162		411.1/.4	412.1		421.2				Brogans Coal
		09	Generation	A	133		411.4							Brogans Coal
		10	Generation	A	167									Brogans Coal
		11	Generation	A	161									Brogans Coal
		12	Generation	A	168		411.4							Brogans Coal
		13	Generation	A	170		411.4	412.1						Brogans Coal
		14	Generation	A	180		411.4							Brogans Coal
		15	Generation	A&B	234		411.4			421				Brogans Coal
		16	Generation	A	163		411.4			421				Brogans Coal
		17	Generation	A	150									Brogans Coal
		18	Generation	A&B	188									Brogans Coal
		19	Generation	A&B	294		411.4	412.1						Brogans Coal
		20	Generation	A&B	140		411.4							Brogans Coal
		21	Generation	A&B	133		411.4							Brogans Coal
		22	Demonstr'n	A&B	291		411.1/.31/.4							Evans Coal
		23	Generation	A&B	293		411.1/.4			421			424	Brogans Coal
		24	Generation	A&B	298									Brogans Coal
		25	Generation	A	161									Brogans Coal
		26	Generation	A	170		411.2/.4							Brogans Coal
		27	Generation	A	185		411.2/.31/.33/.4							Brogans Coal
		28	Generation	A	181									Brogans Coal
		29	Generation	A	145		411.4			421.2				Brogans Coal
		30	Generation	A	152		411.4							Brogans Coal
		31	Generation	A	160									Brogans Coal
			Mg/MTH		4684									

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
84	04	01	Generation	A										Brogans Coal
		02					411.4							Brogans Coal
		03					411.1/.31/.32/.33			421.2				Brogans Coal
		04										423		Brogans Coal
		05					411.32			421.2				Brogans Coal
		06					411.2			421.2				Brogans Coal
		07												Brogans Coal
		08												Brogans Coal
		09	Generation	A	40									Brogans Coal
		10	Generation				411.1/.4							Brogans Coal
		11	Generation	A&B	210									Brogans Coal
		12	Generation	A&B	333		411.4			421.2		423		Brogans Coal
		13	Generation	A&B	368		411.1/.4							Brogans Coal
		14	Demonstr'n	A&B	403									Evans Coal
		15	Generation	A&B	393									Brogans Coal
		16	Generation	A&B	316		411.4	412.2		421				Brogans Coal
		17	Generation	A&B	319		411.4							Brogans Coal
		18	Generation	A&B	319		411.4							Brogans Coal
		19	Generation	A&B	296		411.32/.4							Brogans Coal
		20	Generation	A&B	303									Brogans Coal
		21	Generation	A&B	321									Brogans Coal
		22	Generation	A&B	342									Brogans Coal
		23	Generation	A&B	270									Brogans Coal
		24	Generation	A&B	280									Brogans Coal
		25	Generation	A&B	323		411.2/.4					423		Brogans Coal
		26	Generation	A&B	350		411.1/.2/.4	412.2				423		Brogans Coal
		27	Generation	A&B	336		411.4							Brogans Coal
		28	Generation	A&B	310		411.4							Brogans Coal
		29	Generation	A&B	296		411.4							Brogans Coal
		30	Generation	A&B	286		411.4							Brogans Coal
		31												
			Mg/MTH		6414									
84	05	01	Generation	A&B	278									Brogans Coal
		02	Generation	A&B	292		411.4							Brogans Coal
		03	Generation	A&B	277									Brogans Coal
		04	Generation	A&B	287									Brogans Coal
		05	Generation	A&B	292									Brogans Coal
		06	Generation	A&B	310									Brogans Coal
		07	Generation	A&B	285									Brogans Coal
		08	Generation	A&B	258									Brogans Coal
		09	Generation	A&B	255		411.4							Brogans Coal
		10	Generation	A&B	266									Brogans Coal
		11	Generation	A&B	257									Brogans Coal
		12	Generation	A&B	246									Brogans Coal
		13	Generation	A&B	252									Brogans Coal
		14	Generation	A&B	255									Brogans Coal
		15	Generation	A&B	260									Brogans Coal

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
84	05	16	Generation	A&B	254									Brogans Coal
		17	Generation	A&B	274									Brogans Coal
		18	Generation	A&B	319									Brogans Coal
		19	Generation	A&B	287									Brogans Coal
		20	Generation	A&B	247									Brogans Coal
		21	Generation	A&B	238									Brogans Coal
		22	Generation	A&B	243									Brogans Coal
		23	Generation	A&B	210									Brogans Coal
		24	Generation	A&B	309									Brogans Coal
		25	Generation	A&B	203									Brogans Coal
		26												
		27												
		28												
		29												
		30												
		31												
			Mg/MTH		6654									
84	12	01	Generation	A&B	297									Evans Coal
		02	Generation	A&B	298									Evans Coal
		03	Generation	A&B	291									Evans Coal
		04	Generation	A&B	305									Evans Coal
		05	Generation	A&B	410									Evans Coal
		06	Generation	A	386									Evans Coal
		07	Generation	A	376									Evans Coal
		08	Generation	A	388									Evans Coal
		09	Generation	A	367									Evans Coal
		10	Generation	A	351									Evans Coal
		11												
		12												
		13												
		14											424	
		15												
		16											424	
		17	Generation	A	321									Evans Coal
		18	Generation	A	329									Evans Coal
		19	Generation	A	335									Evans Coal
		20	Generation	A	329									Evans Coal
		21	Generation	A	343									Evans Coal
		22	Generation	A	351									Evans Coal
		23	Generation	A	346									Evans Coal
		24	Generation	A	298									Evans Coal
		25	Generation	A	359									Evans Coal
		26	Generation	A	462					421.2			424	Evans Coal
		27	Generation	A	534					421.2			424	Evans Coal
		28	Generation	A&B	318									Evans Coal
		29	Generation	A&B	318									Evans Coal
		30	Generation	A&B	323			412.1						Evans Coal
		31	Generation	A&B	323			412.1						Evans Coal

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
85	01	01	Generation	A&B	310*			412.1						Evans Coal
		02	Generation	A&B	305									Evans Coal
		03	Generation	A&B	323									Evans Coal
		04	Generation	A&B	502								424	Evans Coal
		05	Generation	A&B	290									Evans Coal
		06	Generation	A&B	361									Evans Coal
		07	Generation	A&B	515									Evans Coal
		08	Generation	A&B	374			412.1						Evans Coal
		09	Generation	A&B	457									Evans Coal
		10	Generation	A&B	472		411.1/.2	412.1		421.2				Evans Coal
		11	Generation	A&B	441									Evans Coal
		12	Generation	A	411									Evans Coal
		13	Generation	A	382									Evans Coal
		14	Generation	A	393	Forced							424	Evans Coal
		15											424	
		16											424	
		17											424	
		18											424	
		19											424	
		20											424	
		21						412.2					424	
		22								421.2				
		23								421.2				
		24												
		25												
		26								421.2				
		27												
		28								421.2				
		29								421.2				
		30								421.2				
		31								421.2				
														*Steam generation figures are for both units combined
85	02	01												
		02												
		03											424	
		04												
		05												
		06											424	
		07											424	
		08					411.33							
		09	Generation	A	54									Evans Coal
		10	Generation	A	145									Evans Coal
		11	Generation	A&B	225		411.4	412.1				423		Evans Coal
		12	Generation	A&B	328			412.1						Evans Coal
		13	Generation	A&B	305									Evans Coal
		14	Generation	A&B	319									Evans Coal
		15	Generation	A&B	336									Evans Coal

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
85	02	16	Generation	A&B	339									Evans Coal
		17	Generation	A&B	353									Evans Coal
		18	Generation	A&B	354									Evans Coal
		19	Generation	A&B	330		411.2							Evans Coal
		20	Generation	A&B	343		411.2							Evans Coal
		21	Generation	A&B	351		411.2							Evans Coal
		22	Generation	A&B	361		411.2							Evans Coal
		23	Generation	A&B	332		411.2			421.2				Evans Coal
		24	Generation	A&B	336					421.2				Evans Coal
		25	Generation	A&B	322									Evans Coal
		26	Generation	A&B	348									Evans Coal
		27	Generation	A&B	343									Evans Coal
		28	Generation	A&B	345	Forced								Evans Coal
		29												
		30												
		31												
			Mg/MTH		6169									
85	03	01	Generation	A&B	328									Evans Coal
		02	Generation	A&B	323									Evans Coal
		03	Generation	A&B	355									Evans Coal
		04	Generation	A&B	351									Evans Coal
		05	Generation	A&B	351									Evans Coal
		06	Generation	A&B	355		411.2			421.2				Evans Coal
		07	Generation	A&B	336								424	Evans Coal
		08	Generation	A&B	337					421.2				Evans Coal
		09	Generation	A&B	315									Evans Coal
		10	Generation	A&B	308									Evans Coal
		11	Generation	A&B	322								424	Evans Coal
		12	Generation	A&B	327			412.1						Evans Coal
		13	Generation	A&B	321		411.33	412.1						Evans Coal
		14	Generation	A&B	290									Evans Coal
		15	Generation	A&B	341									Evans Coal
		16	Generation	A&B	358									Evans Coal
		17	Generation	A&B	329									Evans Coal
		18	Generation	A&B	364									Evans Coal
		19	Generation	A&B	337									Evans Coal
		20	Generation	A&B	319									Evans Coal
		21	Generation	A&B	366									Evans Coal
		22	Generation	A&B	339									Evans Coal
		23	Generation	A&B	316									Evans Coal
		24	Generation	A&B	353			412.1						Evans Coal
		25	Generation	A&B	345									Evans Coal
		26	Generation	A&B	386									Evans Coal
		27	Generation	A&B	356									Evans Coal
		28	Generation	A&B	293									Evans Coal
		29	Generation	A&B	304									Evans Coal
		30	Generation	A&B	313									Evans Coal
		31	Generation	A&B	344					421.2				Evans Coal
			Mg/MTH		10382									

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
85	04	01	Generation	A&B	324									Evans Coal
		02	Generation	A&B	300									Evans Coal
		03	Generation	A&B	285									Evans Coal
		04	Generation	A&B	286									Evans Coal
		05	Generation	A&B	254									Evans Coal
		06	Generation	A&B	269		411.33							Evans Coal
		07	Generation	A&B	299									Evans Coal
		08	Generation	A&B	306									Evans Coal
		09	Generation	A&B	325									Evans Coal
		10	Generation	A&B	324									Evans Coal
		11	Generation	A&B	308		411.33			421.2				Evans Coal
		12	Generation	A&B	322									Evans Coal
		13	Generation	A&B	355									Evans Coal
		14	Generation	A&B	304		411.33							Evans Coal
		15	Generation	A&B	305									Evans Coal
		16	Generation	A&B	267									Evans Coal
		17	Generation	A&B	249					421.2				Evans Coal
		18	Generation	A&B	337		411.33							Evans Coal
		19	Generation	A&B	45				413					Evans Coal
		20	Generation	A&B	-				413					Evans Coal
		21												
		22												
		23												
		24												
		25												
		26												
		27												
		28												
		29												
		30												
		31												
			Mg/MTH		5564									
85	11	01								421.2				
		02												
		03												
		04								421.2				
		05												
		06								421.2				
		07								421.2				
		08												
		09												
		10												
		11												
		12												
		13												
		14												
		15												

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
85	11	16												
		17												
		18												
		19												
		20												
		21												
		22												
		23												
		24												
		25												
		26										423		
		27								421.2		423		
		28								421.2	422.1/2			
		29								421.2	422.1/2			
		30												
		31												
85	12	01												
		02												
		03												
		04								421.2				
		05												
		06												
		07												
		08								421.2				
		09												
		10												
		11					411.4			421.2				
		12										423		
		13												
		14	Generation	A	96		411.1/.2/.4	412.1		421.2	422.1/2			Evans Coal
		15	Generation	A	219			412.1				423	424	Evans Coal
		16	Generation	A	179		411.1			411.2		423		Evans Coal
		17	Generation	A	172	Forced (Stoker Failure)				411.2				Evans Coal
		18					411.2							
		19												
		20												
		21												
		22												
		23												
		24												
		25												
		26												
		27												
		28												
		29												
		30												
		31												

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
86	01	01												
		02								421.2				
		03												
		04												
		05												
		06												
		07	Generation	A	98		411.1							Evans Coal
		08	Generation	A	113		411.2							Evans Coal
		09	Generation	A	32		411.2	412.1						Evans Coal
		10	Generation	A	189									Evans Coal
		11	Generation	A	193		411.2			421.2				Evans Coal
		12	Generation	A	206		411.2							Evans Coal
		13	Generation	A	177		411.2			421.2				Evans Coal
		14	Generation							421.2				Evans Coal
		15	Generation	A	109									Evans Coal
		16	Generation	A	149					421.2	422.1/2			Evans Coal
		17	Generation	A&B	253									Evans Coal
		18	Generation	A&B	351									Evans Coal
		19	Generation	A&B	351									Evans Coal
		20	Generation	A&B	394									Evans Coal
		21	Generation	A&B	368		411.2			421.2				Evans Coal
		22	Generation	A&B	369		411.2							Evans Coal
		23	Generation	A&B	373									Evans Coal
		24	Generation	A&B	404		411.2							Evans Coal
		25	Generation	A&B	339									Evans Coal
		26	Generation	A&B	299									Evans Coal
		27	Generation	A	204			412.1						Evans Coal
		28	Generation	A&B	177									Evans Coal
		29	Generation	A&B	257									Evans Coal
		30	Generation	A&B	286					421.2				Evans Coal
		31	Generation	A&B	272									Evans Coal
					5963									
86	02	01	Generation	A&B	288									Evans Coal
		02	Generation	A&B	264									Evans Coal
		03	Generation	A&B	282									Evans Coal
		04	Generation	A&B	297			412.1						Evans Coal
		05	Generation	A&B	261			412.1						Evans Coal
		06	Generation	A&B	306									Evans Coal
		07	Generation	A&B	318									Evans Coal
		08	Generation	A&B	306		411.2							Evans Coal
		09	Generation	A&B	318		411.1/.2	412.1						Evans Coal
		10	Generation	A&B	306									Evans Coal
		11	Generation	A&B	227		411.2			421.2				Evans Coal
		12	Generation	A	181									Evans Coal
		13	Generation	A	152	Forced	411.4							Evans Coal
		14				(Leaking Tube								
		15				in FBB-1/A)								

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
86	02	16												
		17												
		18												
		19												
		20												
		21												
		22												
		23												
		24												
		25												
		26												
		27												
		28												
		29												
		30												
		31												
			Mg/MTH		3466									
86	03	01												
		02												
		03												
		04												
		05												
		06												
		07												
		08												
		09												
		10								421.2				
		11												
		12												
		13								421.2				
		14								421.2				
		15												
		16												
		17												
		18	Generation	A			411.2/.4							Evans Coal
		19	Generation	A	198		411.1							Evans Coal
		20	Generation	A&B	355		411.2							Evans Coal
		21	Generation	A		Forced								Evans Coal
		22												
		23												
		24												
		25												
		26												
		27												
		28												
		29												
		30												
		31												
			Mg/MTH		553									

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
86	04	01												
		02								421.2				
		03												
		04												
		05												
		06												
		07								421.2				
		08								421.2				
		09												
		10												
		11												
		12												
		13												
		14												
		15												
		16												
		17												
		18												
		19												
		20												
		21												
		22	Generation	A										Evans Coal
		23	Generation	A	229									Evans Coal
		24	Generation	A	222		411.2			421.2				Evans Coal
		25	Generation	A	230									Evans Coal
		26	Generation	A	219									Evans Coal
		27	Generation	A	224									Evans Coal
		28	Generation	A	225					421.2		423		Evans Coal
		29	Generation	A	224								424	Evans Coal
		30	Generation	A	221									Evans Coal
		31												
			Mg/MTH		1794									
86	05	01	Generation	A	217									Evans Coal
		02	Generation	A	204							423		Evans Coal
		03	Generation	A	214									Evans Coal
		04	Generation	A	222									Evans Coal
		05	Generation	A	232									Evans Coal
		06	Generation	A	233									Evans Coal
		07	Generation	A	231									Evans Coal
		08	Generation	A	243									Evans Coal
		09	Generation	A	233									Evans Coal
		10	Generation	A	222									Evans Coal
		11	Generation	A	231									Evans Coal
		12	Generation	A	246									Evans Coal
		13	Generation	A	243									Evans Coal
		14	Generation	A	198									Evans Coal
		15	Generation	A	175									Evans Coal

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-1

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	I&C SYSTEM	BAL. OF PLANT	
86	05	16	Generation	A	188									Evans Coal
		17	Generation	A	179									Evans Coal
		18	Generation	A	165									Evans Coal
		19	Generation	A	174									Evans Coal
		20	Generation	A	227									Evans Coal
		21	Generation	A	213									Evans Coal
		22	Generation	A	200							423		Evans Coal
		23	Generation	A	219									Evans Coal
		24	Generation	A	221									Evans Coal
		25	Generation	A	242									Evans Coal
		26	Generation	A	223									Evans Coal
		27	Generation	A	198									Evans Coal
		28	Generation	A	192									Evans Coal
		29	Generation	A	190									Evans Coal
		30	Generation	A	169									Evans Coal
		31	Generation	A	182									Evans Coal
			Mg/MTH		6522									
86	06	01	Generation	A	173									Evans Coal
		02	Generation	A	195									Evans Coal
		03	Generation	A	213									Evans Coal
		04	Generation	A	201									Evans Coal
		05	Generation	A	143									Evans Coal
		06	Generation	A	143									Evans Coal
		07	Generation	A	135									Evans Coal
		08	Generation	A	132									Evans Coal
		09	Generation	A	135									Evans Coal
		10	Generation	A	125	Forced		412.1						Evans Coal
		11												
		12												
		13					411.32							
		14					411.32							
		15												
		16												
		17												
		18												
		19												
		20												
		21												
		22												
		23												
		24												
		25												
		26												
		27												
		28												
		29												
		30												
		31												

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
82	12	01												
		02												
		03										423		
		04												
		05												
		06												
		07												
		08												
		09												
		10												
		11												
		12												
		13												
		14						412.2		421.2		423		
		15												
		16					411.32/.4			421.2				
		17												
		18												
		19												
		20												
		21												
		22												
		23												
		24												
		25												
		26												
		27												
		28												
		29												
		30												
		31												
83	01	01												
		02												
		03												
		04					411.32/.33							
		05												
		06								421.2				
		07												
		08								421.2				
		09					411.4			421.2				
		10								421.2				
		11						412.2			422.1/2	423	424	
		12					411.32							
		13					411.32							
		14					411.32							
		15												

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
83	01	16												
		17							413					
		18					411.1							
		19												
		20												
		21												
		22												
		23												
		24								421.2				
		25								421.2				
		26								421.2		423	424	
		27												
		28										423		
		29												
		30							413			423		
		31											424	
83	02	01												
		02								421.2		423		
		03												
		04								422.2		423		
		05								422.2				
		06												
		07												
		08												
		09					411.1							
		10												
		11					411.1							
		12												
		13												
		14									422.1/2			
		15									422.1/2			
		16					411.1				422.1/2			
		17									422.1/2			
		18									422.1/2			
		19												
		20												
		21												
		22									422.1/2			
		23										423		
		24												
		25					411.4				422.1/2		424	
		26												
		27												
		28					411.4							
		29												
		30												
		31												

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
83	03	01	Commiss'ing				411.4							
		02	Commiss'ing				411.4							
		03	Commiss'ing				411.4					423		
		04	Commiss'ing				411.4							
		05	Commiss'ing				411.4							
		06	Commiss'ing						413					
		07	Commiss'ing											
		08	Demonstr'n	A			411.4							Evans Coal
		09	Demonstr'n	A			411.1/.4				422.1/2			Evans Coal
		10	Demonstr'n	A	74		411.4	412.2						Evans Coal
		11	Demonstr'n	A	92		411.4							Evans Coal
		12	Demonstr'n	A	91		411.4							Evans Coal
		13	Demonstr'n	A	81		411.4							Evans Coal
		14	Demonstr'n	A	92									Evans Coal
		15	Demonstr'n	A	171		411.1							Evans Coal
		16	Demonstr'n	A	144		411.1							Evans Coal
		17	Demonstr'n	A	124									Evans Coal
		18	Demonstr'n	A	141									Evans Coal
		19	Demonstr'n	A	143									Evans Coal
		20	Demonstr'n	A	143									Evans Coal
		21	Demonstr'n	A	151		411.1/.4			421.2				Evans Coal
		22	Demonstr'n	A	145									Evans Coal
		23	Demonstr'n	A	148									Evans Coal
		24	Demonstr'n	A	140		411.4							Evans Coal
		25	Demonstr'n	A	137		411.4							Evans Coal
		26	Demonstr'n	A	62	Forced	411.4							Evans Coal
		27	Modificat'n				411.2							
		28	Modificat'n											
		29	Modificat'n											
		30	Modificat'n											
		31	Modificat'n											
83	04	01	Modificat'n											
		02	Modificat'n											
		03	Modificat'n											
		04	Modificat'n											
		05	Modificat'n											
		06	Modificat'n								422.1/2			
		07	Modificat'n											
		08	Modificat'n									423		
		09	Modificat'n											
		10	Modificat'n											
		11	Modificat'n											
		12	Modificat'n											
		13	Modificat'n											
		14	Modificat'n					412.1						
		15	Modificat'n											

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
83	04	16	Modificat'n											
		17	Modificat'n											
		18	Modificat'n								422.1/2			
		19	Modificat'n											
		20	Modificat'n											
		21	Modificat'n				411.1							
		22	Modificat'n					412.2						
		23	Modificat'n											
		24	Modificat'n											
		25	Modificat'n					412.2						
		26	Modificat'n											
		27	Modificat'n								422.1/2			
		28	Demonstr'n	A	28									Prince Coal
		29	Demonstr'n	A	173									Prince Coal
		30	Demonstr'n	A	172									Prince Coal
		31	Demonstr'n	A	-									Prince Coal
83	05	01	Demonstr'n	A	131	Forced								Prince Coal
		02	Demonstr'n				411.32							Prince Coal
		03	Demonstr'n				411.32							Prince Coal
		04	Demonstr'n				411.32							Prince Coal
		05	Demonstr'n	A	-		411.32/.4		413	421.2	422.1/2		424	Prince Coal
		06	Demonstr'n	A	68		411.4							Prince Coal
		07	Demonstr'n	A	194		411.4							Prince Coal
		08	Demonstr'n	A	171		411.4							Prince Coal
		09	Demonstr'n	A	343		411.4	412.1	413					Prince Coal
		10	Demonstr'n	A	396		411.4	412.1						Prince Coal
		11	Demonstr'n	A	304		411.4			421				Prince Coal
		12	Demonstr'n	A	288		411.4							Prince Coal
		13	Demonstr'n	A	405		411.4							Prince Coal
		14	Demonstr'n	A	450		411.4							Prince Coal
		15	Demonstr'n	A	150		411.4					423		Prince Coal
		16	Demonstr'n	A	80	Forced	411.4			421		423		Prince Coal
		17	Demonstr'n	A	-		411.1/.31/.33		413					
		18	Demonstr'n	A	-				413					
		19	Demonstr'n	A	-									
		20	Demonstr'n	A	-									
		21	Demonstr'n	A	-									
		22	Demonstr'n	A	-									
		23	Demonstr'n	A	-									
		24	Demonstr'n	A	-		411.4							Prince Coal
		25	Demonstr'n	A	210		411.4							Prince Coal
		26	Demonstr'n	A	253		411.4			421				Prince Coal
		27	Demonstr'n	A	190		411.4							Prince Coal
		28	Demonstr'n	A	131									Prince Coal
		29	Demonstr'n	A	181	Forced								Prince Coal
		30												
		31												

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
83	10	01	Modificat'n											
		02	Modificat'n											
		03	Modificat'n											
		04	Modificat'n											
		05	Modificat'n											
		06	Modificat'n											
		07	Modificat'n											
		08	Modificat'n											
		09	Modificat'n											
		10	Modificat'n											
		11	Modificat'n											
		12	Modificat'n											
		13	Modificat'n											
		14	Modificat'n									423	424	
		15	Modificat'n											
		16	Modificat'n											
		17	Modificat'n											
		18	Modificat'n								422.1/2			
		19	Modificat'n							421.2	422.1/2		424	
		20	Modificat'n											
		21	Modificat'n										424	
		22	Modificat'n											
		23	Modificat'n											
		24	Modificat'n											
		25	Modificat'n				411.4							
		26	Demonstr'n	A	26		411.4						424	Brogans Coal
		27	Demonstr'n	A	89		411.4					423		Brogans Coal
		28	Demonstr'n	A	91		411.4					423		Brogans Coal
		29	Demonstr'n	A	72		411.2/.4					423		Brogans Coal
		30	Demonstr'n	A	123		411.1					423		Brogans Coal
		31	Demonstr'n	A	96									Brogans Coal
83	11	01	Demonstr'n	A	118									Brogans Coal
		02	Demonstr'n	A	144									Brogans Coal
		03	Demonstr'n	A	119									Brogans Coal
		04	Demonstr'n	A	143									Brogans Coal
		05	Demonstr'n	A	141									Brogans Coal
		06	Demonstr'n	A	132									Brogans Coal
		07	Demonstr'n	A	180									Brogans Coal
		08	Demonstr'n	A&B	265									Brogans Coal
		09	Demonstr'n	A&B	244									Brogans Coal
		10	Demonstr'n	A&B	265									Brogans Coal
		11	Demonstr'n	A&B	244									Brogans Coal
		12	Demonstr'n	A&B	226									Brogans Coal
		13	Demonstr'n	A&B	264									Brogans Coal
		14	Demonstr'n	A&B	301									Brogans Coal
		15	Demonstr'n	A&B	293									Brogans Coal

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
83	11	16	Demonstr'n	A&B	338									Brogans Coal
		17	Demonstr'n	A&B	302									Brogans Coal
		18	Demonstr'n	A&B	327									Brogans Coal
		19	Demonstr'n	A&B	334									Brogans Coal
		20	Demonstr'n	A	319		411.4			421.2		423		Brogans Coal
		21	Demonstr'n	A	289						422.1/2			Brogans Coal
		22	Demonstr'n	A	233									Brogans Coal
		23	Demonstr'n	A	234									Brogans Coal
		24	Demonstr'n	A	205									Brogans Coal
		25	Demonstr'n		160									Brogans Coal
		26	Demonstr'n	A&B	201		411.4							Brogans Coal
		27	Demonstr'n	A&B	348		411.31/.4							Brogans Coal
		28	Demonstr'n	A&B	387			412.1				423		Brogans Coal
		29	Demonstr'n	A&B	372							423		Brogans Coal
		30	Demonstr'n	A	359			412.1						Brogans Coal
		31												
					7499									
83	12	01	Demonstr'n	A	240									Brogans Coal
		02	Demonstr'n	A	264							423		Brogans Coal
		03	Demonstr'n	A	321									Brogans Coal
		04	Demonstr'n	A	239									Brogans Coal
		05	Demonstr'n	A	227									Brogans Coal
		06	Demonstr'n	A	336									Brogans Coal
		07	Demonstr'n	A	219									Brogans Coal
		08	Demonstr'n	A	198		411.31/.4					423		Brogans Coal
		09	Demonstr'n	A	210	Forced								Brogans Coal
		10	Modificat'n											
		11	Modificat'n											
		12	Modificat'n											
		13	Modificat'n											
		14	Modificat'n											
		15	Modificat'n											
		16	Modificat'n											
		17	Modificat'n											
		18	Modificat'n											
		19	Modificat'n											
		20	Modificat'n											
		21	Modificat'n											
		22	Modificat'n				411.31	412.2				423	424	
		23	Modificat'n											
		24	Modificat'n											
		25	Modificat'n											
		26	Modificat'n											
		27	Modificat'n											
		28	Modificat'n											
		29	Modificat'n											
		30	Modificat'n											
		31	Modificat'n											
					2254									

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
84	01	01	Modificat'n											
		02	Modificat'n											
		03	Modificat'n											
		04	Modificat'n											
		05	Modificat'n										424	
		06	Modificat'n									423	424	
		07	Modificat'n											
		08	Modificat'n											
		09	Modificat'n										424	
		10	Modificat'n											
		11	Modificat'n											
		12	Modificat'n							421				
		13	Modificat'n											
		14	Modificat'n											
		15	Modificat'n											
		16	Modificat'n											
		17	Modificat'n											
		18	Modificat'n											
		19	Modificat'n											
		20	Modificat'n											
		21	Modificat'n											
		22	Modificat'n											
		23	Modificat'n								422.1/2			
		24	Modificat'n											
		25	Modificat'n											
		26	Modificat'n											
		27	Modificat'n											
		28	Modificat'n											
		29	Modificat'n											
		30	Modificat'n											
		31	Modificat'n											
84	02	01	Modificat'n											
		02	Modificat'n											
		03	Modificat'n											
		04	Modificat'n											
		05	Modificat'n											
		06	Modificat'n											
		07	Modificat'n											
		08	Modificat'n											
		09	Modificat'n											
		10	Modificat'n											
		11	Modificat'n											
		12	Modificat'n											
		13	Modificat'n											
		14	Modificat'n											
		15	Modificat'n				411.1						424	

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
84	02	16	Modificat'n				411.31							
		17	Modificat'n				411.31/.33							
		18	Modificat'n											
		19	Modificat'n											
		20	Modificat'n				411.2							
		21	Generation	A	92		411.1/.4							Brogans Coal
		22	Generation	A	253		411.31/.4	412.1						Brogans Coal
		23	Demonstr'n	A&B	259			412.1						Brogans Coal
		24	Generation	A&B	365			412.1						Brogans Coal
		25	Demonstr'n	A&B	426									Brogans Coal
		26	Generation	A&B	359									Brogans Coal
		27	Generation	A&B	329		411.1/.4						424	Brogans Coal
		28	Generation	A&B	168		411.1/.33/.4				422.1/2	423	424	Brogans Coal
		29	Generation	A&B	190		411.4						424	Brogans Coal
		30												
		31												
			Mg/MTH		2441									
84	03	01	Generation	A&B	288		411.4						424	Brogans Coal
		02	Generation	A&B	345		411.4						424	Brogans Coal
		03	Generation	A&B	326									Brogans Coal
		04	Generation	A&B	326									Brogans Coal
		05	Generation	A&B	318		411.33/.4					423		Brogans Coal
		06	Generation	A&B	259		411.4	412.2		421.2				Brogans Coal
		07	Generation	A	163		411.4					423		Brogans Coal
		08	Generation	A	170		411.4			421.2				Brogans Coal
		09	Generation	A	192		411.4							Brogans Coal
		10	Generation	A	150									Brogans Coal
		11	Generation	A	175									Brogans Coal
		12	Generation	A	177		411.4							Brogans Coal
		13	Generation	A	174		411.4	412.1						Brogans Coal
		14	Generation	A	184		411.4	412.1						Brogans Coal
		15	Generation	A	23	Forced	411.2/.33			421				Brogans Coal
		16								421				Brogans Coal
		17												Brogans Coal
		18												Brogans Coal
		19					411.31/.32							Brogans Coal
		20					411.33							Brogans Coal
		21					411.33							Brogans Coal
		22												Brogans Coal
		23								421			424	Brogans Coal
		24												Brogans Coal
		25												Brogans Coal
		26												Brogans Coal
		27												Brogans Coal
		28	Generation	A	4		411.2/.4							Brogans Coal
		29	Generation	A	152		411.4			421.2				Brogans Coal
		30	Generation	A&B	253		411.4							Brogans Coal
		31	Generation	A&B	239									Brogans Coal
			Mg/MTH		3918									

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS	GENERATED Mg/DAY		FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
84	04	01	Generation	A&B	No Record									Brogans Coal
		02	Generation	A&B	No Record		411.4							Brogans Coal
		03	Generation	A&B	No Record		411.2/.4			421.2				Brogans Coal
		04	Generation	A&B	No Record		411.2/.4					423		Brogans Coal
		05	Generation	A&B	No Record		411.2/.4			421.2				Brogans Coal
		06	Generation	A&B	No Record		411.1/.4			421.2				Brogans Coal
		07	Generation	A&B	No Record									Brogans Coal
		08	Generation	A&B	No Record									Brogans Coal
		09	Generation	A&B	No Record									Brogans Coal
		10	Generation	A&B	No Record									Brogans Coal
		11	Generation	A&B	No Record									Brogans Coal
		12	Generation	A	No Record		411.4			421.2		423		Brogans Coal
		13					411.1							
		14												
		15												
		16								421				
		17					411.1							
		18					411.1							
		19												
		20												
		21												
		22												
		23												
		24												
		25										423		
		26										423		
		27												
		28												
		29												
		30												
		31												

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
84	06	01												
		02												
		03												
		04												
		05												
		06												
		07												
		08												
		09												
		10												
		11	Generation	A	30									
		12	Generation	A	138		411.1							
		13	Generation	A	138		411.1							
		14	Generation	A	31	Planned								
		15												
		16												
		17					411.1							
		18												
		19												
		20												
		21												
		22												
		23												
		24												
		25												
		26												
		27												
		28												
		29												
		30												
		31												
			Mg/MTH		337									

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
84	10	01												
		02												
		03												
		04												
		05												
		06												
		07												
		08												
		09												
		10												
		11												
		12												
		13												
		14												
		15												
		16	Generation	A	67									Evans Coal
		17	Generation	A&B	240									Evans Coal
		18	Generation	A&B	196									Evans Coal
		19	Generation	A&B	244									Evans Coal
		20	Generation	A&B	218									Evans Coal
		21	Generation	A&B	221									Evans Coal
		22	Generation	A&B	216									Evans Coal
		23	Generation	A&B	235									Evans Coal
		24	Generation	A&B	242									Evans Coal
		25	Generation	A&B	241									Evans Coal
		26	Generation	A&B	267									Evans Coal
		27	Generation	A&B	284									Evans Coal
		28	Generation	A&B	255									Evans Coal
		29	Generation	A&B	244									Evans Coal
		30	Generation	A&B	274									Evans Coal
		31	Generation	A&B	257									Evans Coal
			Mg/MTH		3701									
84	11	01	Generation	A&B	284									Evans Coal
		02	Generation	A&B	255									Evans Coal
		03	Generation	A&B	299									Evans Coal
		04	Generation	A&B	287									Evans Coal
		05	Generation	A&B	233									Evans Coal
		06	Generation	A&B	203									Evans Coal
		07	Generation	A&B	188									Evans Coal
		08	Demonstr'n	A	93									Minto Coal
		09	Demonstr'n	A	85									Brogans Unwashed Coal
		10	Demonstr'n	A	97									Novaco Coal
		11	Demonstr'n	A	102									Evans Coal
		12	Generation	A	98									Evans Coal
		13	Generation	A&B	193									Evans Coal
		14	Generation	A&B	286									Evans Coal
		15	Generation	A&B	335									Evans Coal

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
84	11	16	Generation	A&B	267									Evans Coal
		17	Generation	A&B	280									Evans Coal
		18	Generation	A&B	358									Evans Coal
		19	Generation	A&B	341									Evans Coal
		20	Generation	A&B	360									Evans Coal
		21	Generation	A&B	332									Evans Coal
		22	Generation	A&B	315									Evans Coal
		23	Generation	A&B	300									Evans Coal
		24	Generation	A&B	318									Evans Coal
		25	Generation	A&B	331									Evans Coal
		26	Generation	A&B	308									Evans Coal
		27	Generation	A&B	270									Evans Coal
		28	Generation	A&B	295									Evans Coal
		29	Generation	A	270									Evans Coal
		30	Generation	A	267									Evans Coal
		31												
			Mg/MTH		7650									
84	12	01												
		02												
		03												
		04	Generation	A	305									Evans Coal
		05	Generation	A&B	410									Evans Coal
		06	Generation	A&B	386									Evans Coal
		07	Generation	A&B	376									Evans Coal
		08	Generation	A&B	388									Evans Coal
		09	Generation	A&B	367									Evans Coal
		10	Generation	A&B	351									Evans Coal
		11	Generation	A&B	295									Evans Coal
		12	Generation	A&B	258									Evans Coal
		13	Generation	A&B	206									Evans Coal
		14	Generation	A&B	344								424	Evans Coal
		15	Generation	A&B	312		411.2							Evans Coal
		16	Generation	A&B	328		411.2/.33						424	Evans Coal
		17	Generation	A&B	321									Evans Coal
		18	Generation	A&B	329									Evans Coal
		19	Generation	A&B	335									Evans Coal
		20	Generation	A&B	329									Evans Coal
		21	Generation	A&B	343									Evans Coal
		22	Generation	A&B	351									Evans Coal
		23	Generation	A&B	346									Evans Coal
		24	Generation	A&B	298									Evans Coal
		25	Generation	A&B	359									Evans Coal
		26	Generation	A&B	462					421.2			424	Evans Coal
		27	Generation	A&B	534					421.2			424	Evans Coal
		28	Generation	A&B	318		411.33							Evans Coal
		29					411.33	412.1						
		30					411.33							
		31					411.33							

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
85	01	01					411.33							
		02					411.33							
		03					411.33							
		04					411.33						424	
		05					411.33							
		06					411.33							
		07					411.33							
		08	Generation	A	374(*)		411.1/.33							Evans Coal
		09	Generation	A	457		411.33							Evans Coal
		10	Generation	A	472		411.33			421.2				Evans Coal
		11	Generation	A&B	441									Evans Coal
		12	Generation	A&B	411									Evans Coal
		13	Generation	A&B	382									Evans Coal
		14	Generation	A&B	393								424	Evans Coal
		15	Generation	A&B	367								424	Evans Coal
		16	Generation	A&B	377								424	Evans Coal
		17	Generation	A&B	354			412.2					424	Evans Coal
		18	Generation	A&B	365								424	Evans Coal
		19	Generation	A&B	325								424	Evans Coal
		20	Generation	A&B	328			412.2					424	Evans Coal
		21	Generation	A&B	356			412.1					424	Evans Coal
		22	Demonstr'n	A&B	436		411.2/.4	412.1		421.2				Minto Coal
		23	Demonstr'n	A&B	397		411.2/.4			421.2				Novaco Coal
		24	Demonstr'n	A&B	288		411.4							Novaco Coal
		25	Demonstr'n	A&B	305		411.4							Minto Coal
		26	Generation	A&B	366					421.2				Evans Coal
		27	Generation	A&B	341									Evans Coal
		28	Generation	A&B	352					421.2				Evans Coal
		29	Generation	A&B	329					421.2				Evans Coal
		30	Generation	A&B	379					421.2				Evans Coal
		31	Generation	A&B	342		411.33			421.2				Evans Coal
														*Steam generation figures are for both units combined
85	02	01	Generation	A&B	330									Evans Coal
		02	Generation	A&B	348									Evans Coal
		03	Generation	A&B	330									Evans Coal
		04	Generation	A&B	332								424	Evans Coal
		05	Generation	A&B	369									Evans Coal
		06	Generation	A&B	359								424	Evans Coal
		07	Generation	A&B	361								424	Evans Coal
		08	Generation	A&B	349			412.1						Evans Coal
		09	Generation	A&B	32									Evans Coal
		10	Generation	A&B	259									Evans Coal
		11	Generation	A&B	103	Forced	411.32/.4					423		Evans Coal
		12												
		13					411.33/.4							
		14												
		15												

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
85	02	16												
		17												
		18												
		19												
		20												
		21												
		22					411/.4							
		23					411/.4			421.2				
		24					411/.4			421.2				
		25					411/.4							
		26												
		27												
		28												
		29												
		30												
		31												
			Mg/MTH		3172									

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
85	05	01												
		02												
		03												
		04												
		05					411.4							
		06	Generation	A	68		411.31/.4							Evans Coal
		07	Generation	A	151		411.31							Evans Coal
		08	Generation	A	164									Evans Coal
		09	Generation	A	103							423		Evans Coal
		10	Generation	A	155							423		Evans Coal
		11	Generation	A	146									Evans Coal
		12	Generation	A	158									Evans Coal
		13	Generation	A	161									Evans Coal
		14	Generation	A	153									Evans Coal
		15	Generation	A	140									Evans Coal
		16	Generation	A	158									Evans Coal
		17	Generation	A	154									Evans Coal
		18	Generation	A	161									Evans Coal
		19	Generation	A	176									Evans Coal
		20	Generation	A	16	Planned								Evans Coal
		21												
		22												
		23												
		24												
		25												
		26												
		27												
		28												
		29												
		30												
		31												
			Mg/MTh		2084									

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
85	10	01												
		02												
		03												
		04	Generation	A	-									Evans Coal
		05	Generation	A	53		411.4							Evans Coal
		06	Generation											Evans Coal
		07	Generation											Evans Coal
		08	Generation	A	-									Evans Coal
		09	Generation	A	174		411.4							Evans Coal
		10	Generation	A	181		411.2							Evans Coal
		11	Generation	A	239		411.2	412.1						Evans Coal
		12	Generation	A	247			412.2						Evans Coal
		13	Generation	A	229									Evans Coal
		14	Generation	A	217									Evans Coal
		15	Generation	A	133	Forced	411.4	412.1						Evans Coal
		16	Generation											Evans Coal
		17	Generation											Evans Coal
		18	Generation											Evans Coal
		19	Generation											Evans Coal
		20	Generation											Evans Coal
		21	Generation											Evans Coal
		22	Generation											Evans Coal
		23	Generation											Evans Coal
		24	Generation	A	182									Evans Coal
		25	Generation	A	209		411.1							Evans Coal
		26	Generation	A	239									Evans Coal
		27	Generation	A	146									Evans Coal
		28	Generation		-									Evans Coal
		29	Generation	A	78									Evans Coal
		30	Generation	A&B	252									Evans Coal
		31	Generation	A&B	295									Evans Coal
			Mg/MTH		2874									
85	11	01	Generation	A&B	296					421.2				Evans Coal
		02	Generation	A&B	278									Evans Coal
		03	Generation	A&B	278		411.2							Evans Coal
		04	Generation	A&B	274			412.1		421.2				Evans Coal
		05	Generation	A&B	270									Evans Coal
		06	Generation	A	228									Evans Coal
		07	Generation	A	224					421.2				Evans Coal
		08	Generation	A	240					421.2				Evans Coal
		09	Generation	A	261									Evans Coal
		10	Generation	A&B	270									Evans Coal
		11	Generation	A&B	277									Evans Coal
		12	Generation	A&B	305		411.2/.4	412.1						Evans Coal
		13	Generation	A	156		411.4							Evans Coal
		14	Generation	-										Evans Coal
		15	Generation	A	248									Evans Coal

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
85	11	16	Generation	A	263									Evans Coal
		17	Generation	A	274									Evans Coal
		18	Generation	A	263									Evans Coal
		19	Generation	A	240									Evans Coal
		20	Generation	A	242									Evans Coal
		21	Generation	A	252									Evans Coal
		22	Generation	A	251			412.1						Evans Coal
		23	Generation	A	251		411.2							Evans Coal
		24	Generation	A	268									Evans Coal
		25	Generation	A&B	313									Evans Coal
		26	Generation	A&B	384							423		Evans Coal
		27	Generation	A&B	356					421.2		423		Evans Coal
		28	Generation	A&B	353		411.2			421.2	422.1/2			Evans Coal
		29	Generation	A&B	361					421.2	422.1/2			Evans Coal
		30	Generation	A&B	352									Evans Coal
		31												
			Mg/MTH		8028									
85	12	01	Generation	A&B	328									Evans Coal
		02	Generation	A&B	324									Evans Coal
		03	Generation	A&B	392									Evans Coal
		04	Generation	A&B	435					421.2				Evans Coal
		05	Generation	A&B	394									Evans Coal
		06	Generation	A&B	387									Evans Coal
		07	Generation	A&B	399									Evans Coal
		08	Generation	A&B	365					421.2				Evans Coal
		09	Generation	A&B	374									Evans Coal
		10	Generation	A&B	385									Evans Coal
		11	Generation	A&B	356		411.2			421.2				Evans Coal
		12	Generation	A&B	370		411.2					423		Evans Coal
		13	Generation	A&B	369									Evans Coal
		14	Generation	A&B	338					421.2	422.1/2			Evans Coal
		15	Generation	A	452							423	424	Evans Coal
		16	Generation	A	379							423		Evans Coal
		17	Generation	A	380									Evans Coal
		18	Generation	A&B	311		411.4							Evans Coal
		19	Generation	A&B	406		421.4							Evans Coal
		20	Generation	A&B	418		411.2							Evans Coal
		21	Generation	A&B	410									Evans Coal
		22	Generation	A&B	419			412.2						Evans Coal
		23	Generation	A&B	413									Evans Coal
		24	Generation	A&B	353									Evans Coal
		25	Generation	A&B	325									Evans Coal
		26	Generation	A&B	409			412.1						Evans Coal
		27	Generation	A&B	437									Evans Coal
		28	Generation	A&B	371									Evans Coal
		29	Generation	A&B	371									Evans Coal
		30	Generation	A&B	364									Evans Coal
		31	Generation	A&B	389									Evans Coal
			Mg/MTH		11823									

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
86	01	01	Generation	A&B	333									Evans Coal
		02	Generation	A&B	374		411.2			421.2				Evans Coal
		03	Generation	A&B	410			412.1						Evans Coal
		04	Generation	A&B	388									Evans Coal
		05	Generation	A&B	395		411.2							Evans Coal
		06	Generation	A&B	413									Evans Coal
		07	Generation	A&B	379									Evans Coal
		08	Generation	A&B	338		411.2							Evans Coal
		09	Generation	A&B	342			412.1						Evans Coal
		10	Generation	A	169									Evans Coal
		11	Generation	A	200					421.2				Evans Coal
		12	Generation	A	209									Evans Coal
		13	Generation	A	192					421.2				Evans Coal
		14	Generation	A&B	250				413	421.2				Evans Coal
		15	Generation	A&B	386									Evans Coal
		16	Generation	A&B	372					421.2	422.1/2			Evans Coal
		17	Generation	A&B	77	Forced								Evans Coal
		18	Generation											Evans Coal
		19	Generation											Evans Coal
		20	Generation											Evans Coal
		21	Generation							421.2				Evans Coal
		22	Generation											Evans Coal
		23	Generation											Evans Coal
		24	Generation											Evans Coal
		25	Generation	A	74		411.2							Evans Coal
		26	Generation	A	118		411.2							Evans Coal
		27	Generation	A	175									Evans Coal
		28	Generation	A	156									Evans Coal
		29	Generation	A	194									Evans Coal
		30	Generation	A	136					421.2				Evans Coal
		31	Generation	A	153									Evans Coal
			Mg/MTH		6233									
86	02	01	Generation	A	138									Evans Coal
		02	Generation	A	144									Evans Coal
		03	Generation	A	154									Evans Coal
		04	Generation	A	165									Evans Coal
		05	Generation	A	158									Evans Coal
		06	Generation	A	160									Evans Coal
		07	Generation	A	160									Evans Coal
		08	Generation	A	134									Evans Coal
		09	Generation	A	142									Evans Coal
		10	Generation	A	125									Evans Coal
		11	Generation	A	152					421.2				Evans Coal
		12	Generation	A	198									Evans Coal
		13	Generation	A&B	246		411/.4							Evans Coal
		14	Generation	A&B	407									Evans Coal
		15	Generation	A&B	396									Evans Coal

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED Mg/DAY	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS			FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
86	02	16	Generation	A&B	395									Evans Coal
		17	Generation	A&B	403									Evans Coal
		18	Generation	A&B	377									Evans Coal
		19	Generation	A&B	378		411.2							Evans Coal
		20	Generation	A&B	380		411.1/.2	412.1						Evans Coal
		21	Generation	A&B	366									Evans Coal
		22	Generation	A&B	364									Evans Coal
		23	Generation	A&B	403									Evans Coal
		24	Generation	A&B	381			412.2						Evans Coal
		25	Generation	A&B	396			412.1						Evans Coal
		26	Generation	A&B	389									Evans Coal *
		27	Generation	A&B	407									Evans Coal *
		28	Generation	A&B	410	Forced		412.2						Evans Coal *
		29												
		30												
		31												
			Mg/MTH		7928									
86	03	01	Generation	A&B	416									Evans Coal *
		02	Generation	A&B	421									Evans Coal *
		03	Generation	A&B	413									Evans Coal *
		04	Generation	A&B	404									Evans Coal *
		05	Generation	A&B	383			412.2						Evans Coal *
		06	Generation	A&B	421									Evans Coal *
		07	Generation	A&B	405									Evans Coal *
		08	Generation	A&B	401									Evans Coal *
		09	Generation	A&B	403									Evans Coal *
		10	Generation	A&B	401			412.1		421.2				Evans Coal *
		11	Generation	A&B	415									Evans Coal *
		12	Generation	A&B	413									Evans Coal *
		13	Generation	A&B	421					421.2				Evans Coal *
		14	Generation	A&B	402					421.2				Evans Coal *
		15	Generation	A&B	416									Evans Coal *
		16	Generation	A&B	402									Evans Coal *
		17	Generation	A&B	399									Evans Coal *
		18	Generation	A&B	319		411.4							Evans Coal *
		19	Generation	A		Forced								Evans Coal *
		20	Generation											Evans Coal *
		21	Generation	A&B	382									Evans Coal *
		22	Generation	A&B	460									Evans Coal *
		23	Generation	A&B	386									Evans Coal *
		24	Generation	A&B	386									Evans Coal *
		25	Generation	A&B	431									Evans Coal *
		26	Generation	A&B	396									Evans Coal *
		27	Generation	A&B	360									Evans Coal
		28	Generation	A&B	325									Evans Coal
		29	Generation	A&B	343									Evans Coal
		30	Generation	A&B	300			412.1						Evans Coal
		31	Generation	A&B	299									Evans Coal
			Mg/MTH		11320									

---

* Emissions testing by U.S. Environmental Protection Agency (EPA).

DAILY OPERATIONAL RECORD OF FLUIDIZED BED BOILER FBB-2

DATE			OPERATION		STEAM GENERATED	TYPE OF OUTAGE	REFERENCES TO PART NUMBERS IN PART 4 'PLANT OPERATION'							NOTES/REMARKS
Y	M	D	TYPE	BEDS	Mg/DAY		FLUID BED SYSTEM	ASH HANDLING SYSTEM	DRAFT SYSTEM	FUEL SYSTEM	SORBENT SYSTEM	E&C SYSTEM	BAL. OF PLANT	
86	04	01	Generation	A&B	306		411.2							Evans Coal
		02	Generation	A&B	300					421.2				Evans Coal
		03	Generation	A&B	333									Evans Coal
		04	Generation	A&B	314									Evans Coal
		05	Generation	A&B	334		411.2							Evans Coal
		06	Generation	A&B	224		411.1/.2							Evans Coal
		07	Generation	A&B	333					421.2				Evans Coal
		08	Generation	A&B	226					421.2				Evans Coal
		09	Generation	A&B	224									Evans Coal
		10	Generation	A&B	327			412.1						Evans Coal
		11	Generation	A&B	283									Evans Coal
		12	Generation	A	256									Evans Coal
		13	Generation	A	251									Evans Coal
		14	Generation	A	251									Evans Coal
		15	Generation	A	257			412.1						Evans Coal
		16	Generation	A	259									Evans Coal
		17	Generation	A	262		411.2							Evans Coal
		18	Generation	A	259									Evans Coal
		19	Generation	A	269									Evans Coal
		20	Generation	A	263									Evans Coal
		21	Generation	A	242		411.2							Evans Coal
		22	Demonstr'n	A	218	Planned								Novaco Coal
		23					411.4							
		24								421.2				
		25												
		26												
		27												
		28								421.2		423		
		29											424	
		30												
		31												
			Mg/MTH		6295									

PART 5

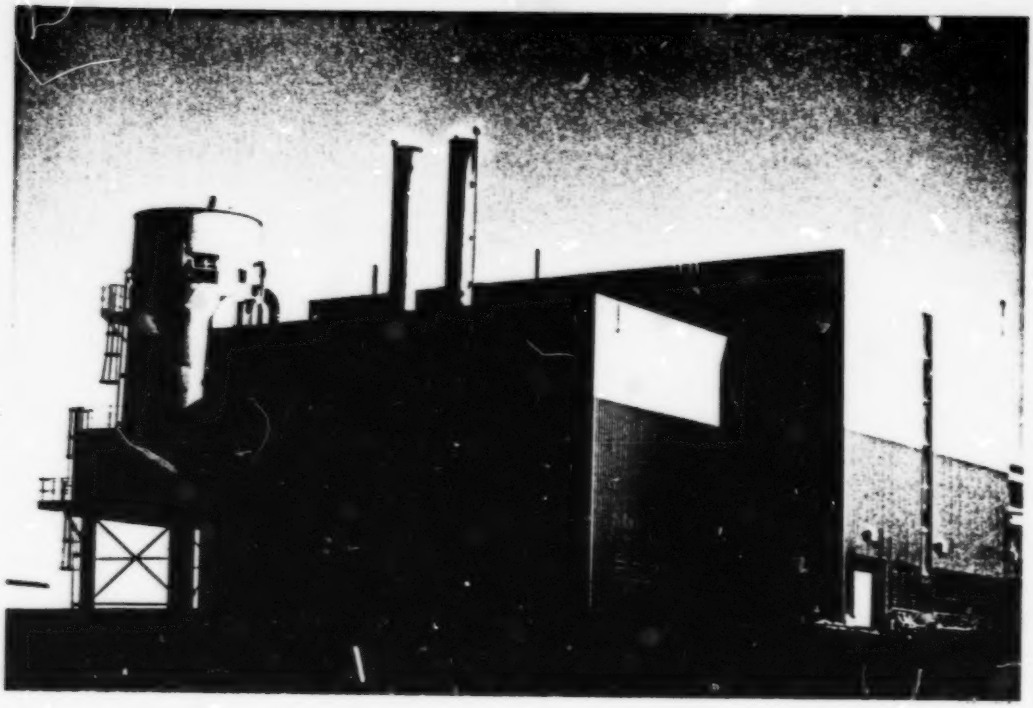
PHOTOGRAPHS

The following photographs are enclosed:

Photograph Number	Caption
1	Outside view of FBB Plant at CFB-Summerside.
2	Boiler water walls before startup.
3	Boiler water walls after 600 hours of operation, before refractory installation.
4	June 1983. View of combustion chamber after installation of refractory, after 600 hours of operation.
5	June 1983. Polishing on in-bed tubes.
6	January 1985. Sheds and tubes showing evidence of polishing.
7	January 1985. Close-up of sheds and polishing on tubes.
8	February 1985. Sheds and tubes in the area of tube failure.
9	Tube failure with metal removed.
10	September 1985. New studs on waterwalls.
11	September 1985. Closer view of studs on waterwalls.
12	January 1986. Studs on waterwalls showing trapped ash after 2500 hours of operation.
13	January 1986. Closer view of studs on waterwalls, cleaner area.
14	January 1986. Studs on waterwalls, closer view, showing some rounding on the free ends of the studs.
15	January 1986. Studs on waterwalls, general view, showing heavy deposit.
16	January 1986. Studs on waterwalls, closer view showing caps of deposit.
17	June 1983. In-bed tubes after installation of refractory.

Photograph Number	Caption
18	February 1984. Top of in-bed tube showing spalling of alonized layer.
19	February 1984. Underside of in-bed tubes showing loss of alonizing.
20	September 1985. Cross-section of eroded in-bed tube.
21	January 1986. Top view of in-bed tube; no polishing after 1500 hours of operation.
22	January 1986. In-bed tubes; some polishing on rods.
23	January 1986. Underside of lower bend of in-bed tube, showing some polishing on rods.
24	May 1986. View in Bed A following 4200 hours of operation after studding the water wall tubes.
25	May 1986. Waterwall studs showing heavy deposit and rounding.
26	May 1986. View in Bed B following 2500 hours of operation after studding and rodding.
27	May 1986. In-bed tubes and limestones feed point.
28	SUmmer 1985. Lower elbow of z-section of the modified fly ash reinjection system installed.
29	Summer 1985. Upper elbow of z-section of modified fly ash reinjection system installed.
30	Connection to furnace wall; air nozzle of the modified fly ash reinjection system.
31	Reinjection port showing air nozzle.
32	1984. Permalok reinjection system for cyclone ash.
33	Early 1985. Typical bulging of Lavalox. Some of it had to be replaced within one year of installation.
34	September 1985. Section of studs showing weld penetration.
35	September 1985. Bed A after installation of additional bubble caps and heavy sleeve on thermocouple well.

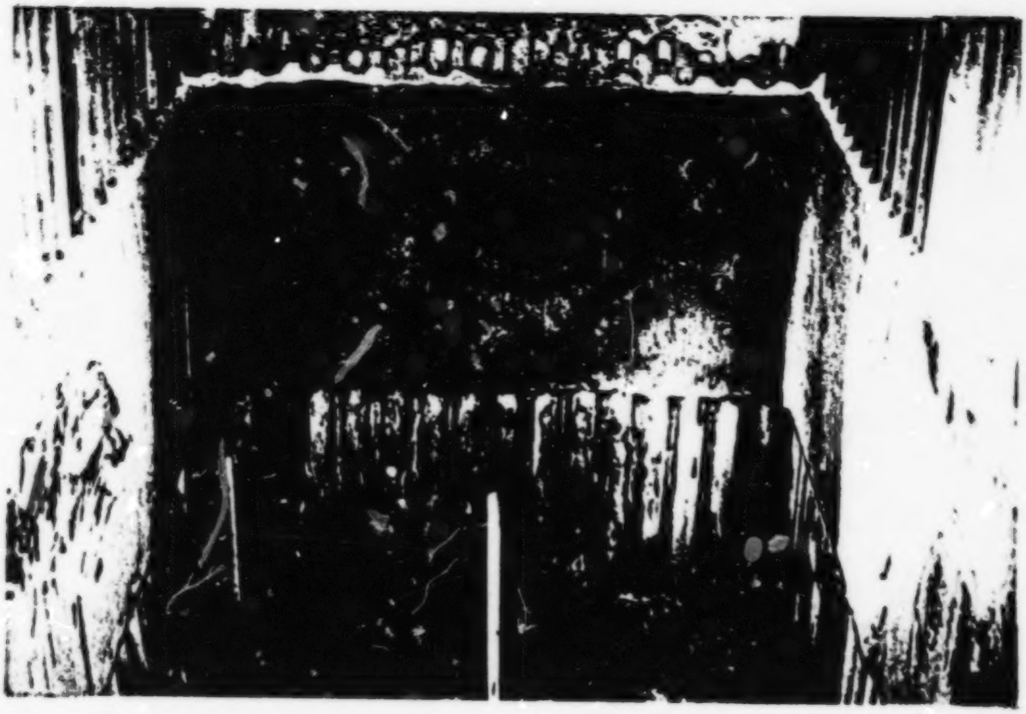
Photograph Number	Caption
36	Interbed transfer gate, as installed, and the unprotected tubes it slides against.
37	Interbed transfer gate, as installed, shown jammed partly open.
38	September 1985. FBB-2. First version of interbed transfer opening which proved too small.
39	September 1985. FBB-2. Second and successful interbed transfer opening.
40	Reinjection blowers as installed. They were noisy and had to be enclosed. One is now rendered redundant by the new reinjection system.
41	View of spreader stokers on front of boiler.
42	FBB-1. Edge view of distributor at hatch into windbox. This is the area that was not sealed perfectly on one occasion, resulting in air leakage from the windbox across the distributor, which eroded a hole in the distributor.
43	FBB-1. Hole in distributor plate which resulted from the leakage described in picture no. 42.
44	Example of erosion caused by a bubble cap pointed at an air nozzle on the periphery of the bed.
45	Firing floor in front of boiler when trying to cope with wet coal. Spreader stoker pans had to be removed to prevent jamming. This resulted in the coal piling up on the floor.



1. Outside view of FBB Plant at CFB-Summerside. (VR:1)

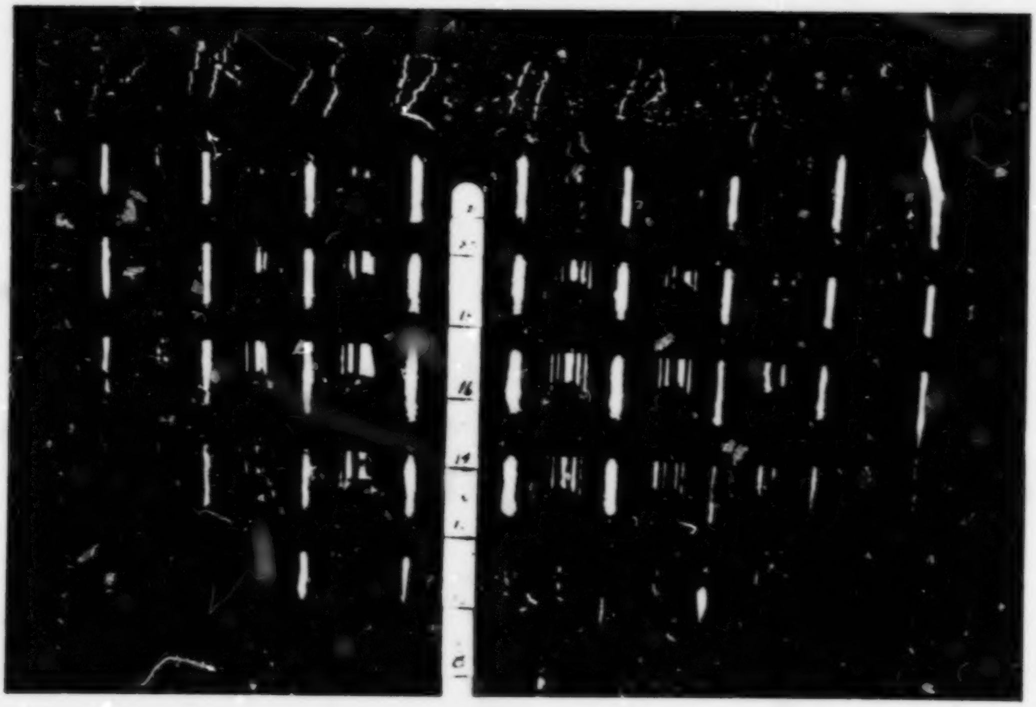
2. Boiler water walls before startup. (VR:3)

3. Boiler water walls after 600 hours of operation, before refractory installation. (VR: 3a)

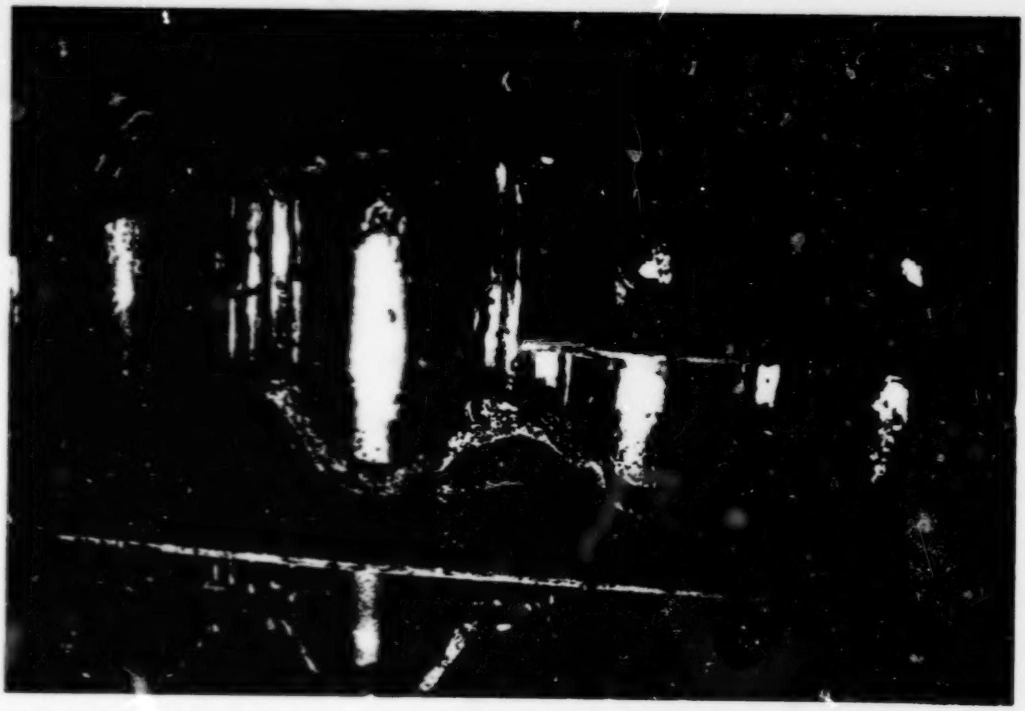


4. June 1983. View of combustion chamber after installation of refractory, after 600 hours of operation. (VR:5)

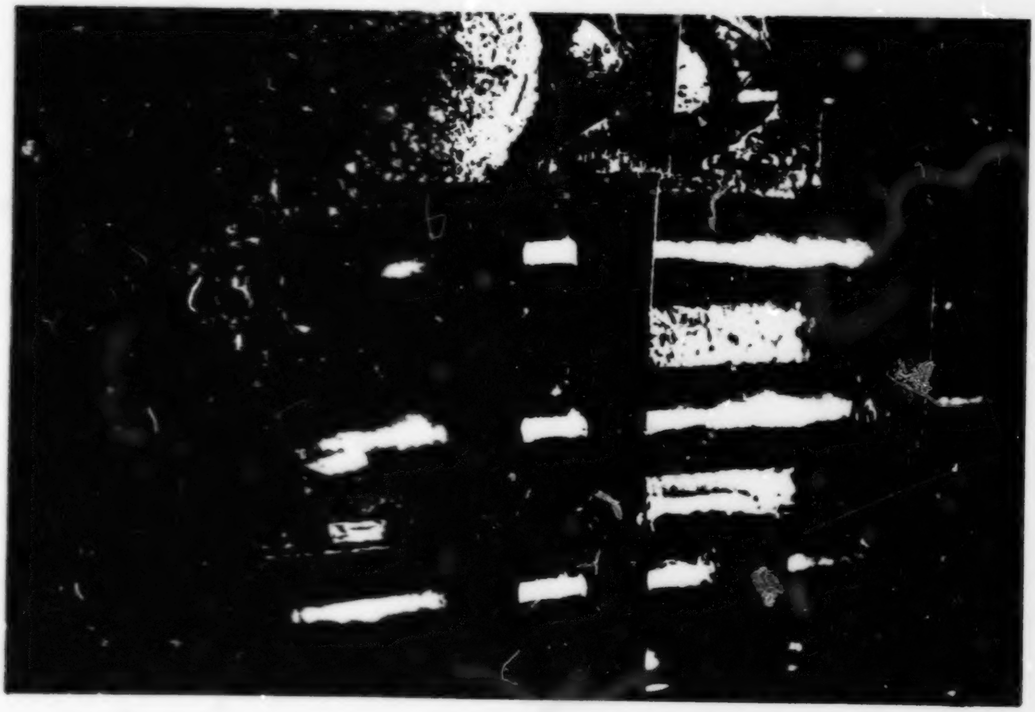
5. June 1983. Polishing on in-bed tubes (VR:6)



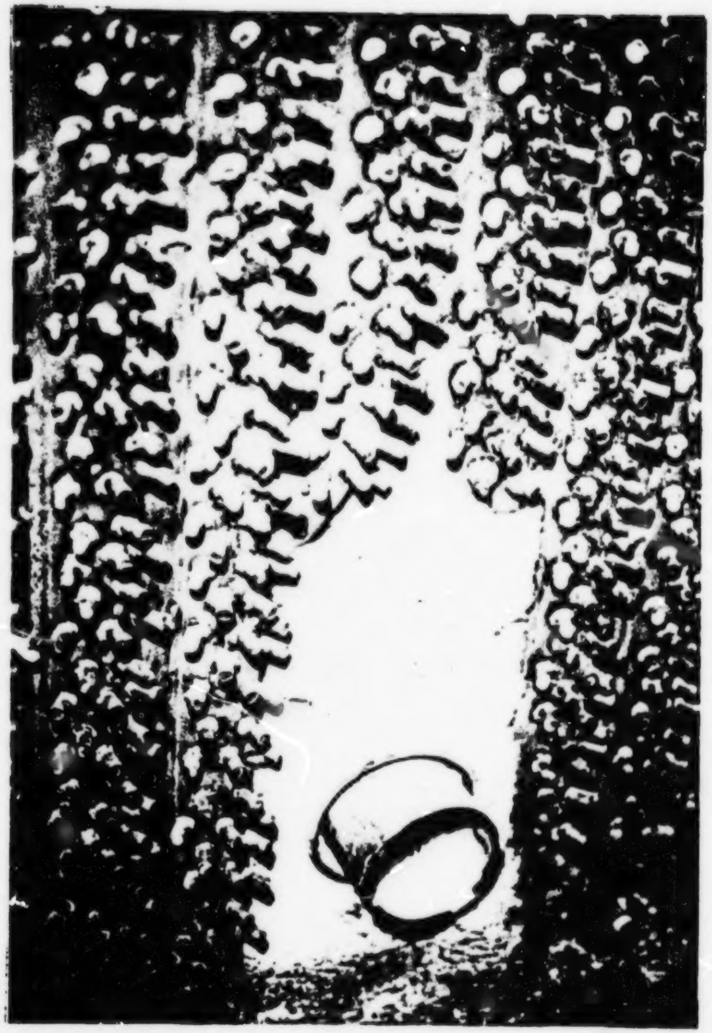
6. January 1985. Sheds and tubes showing evidence of polishing. (VR:8)



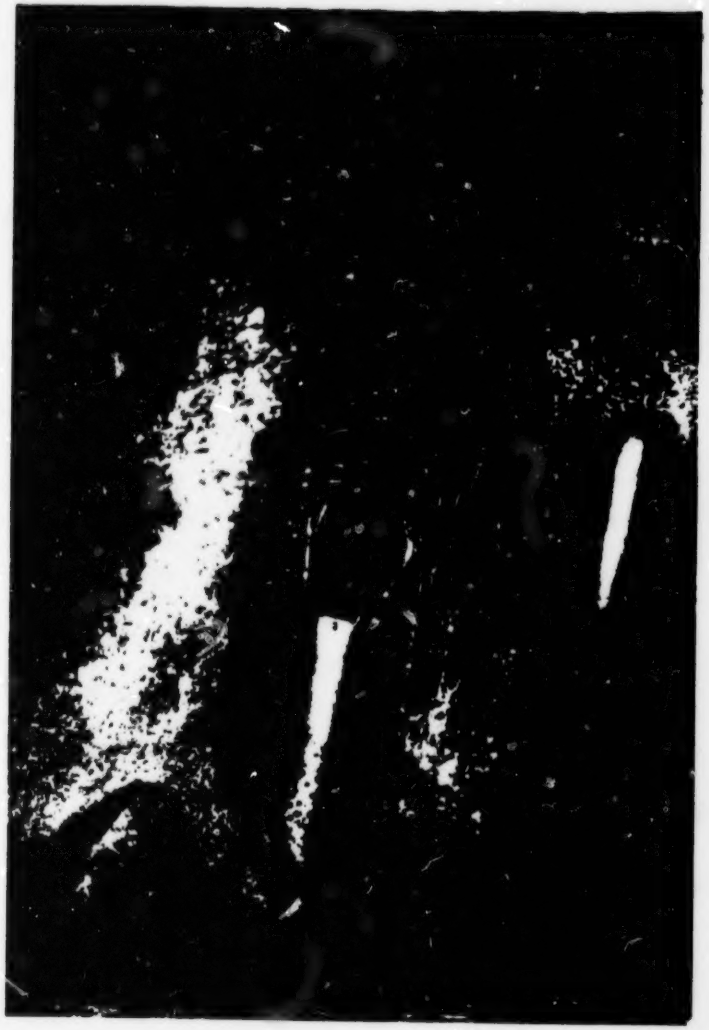
7. January 1985. Close-up of sheds and polishing on tubes. (VR:9)



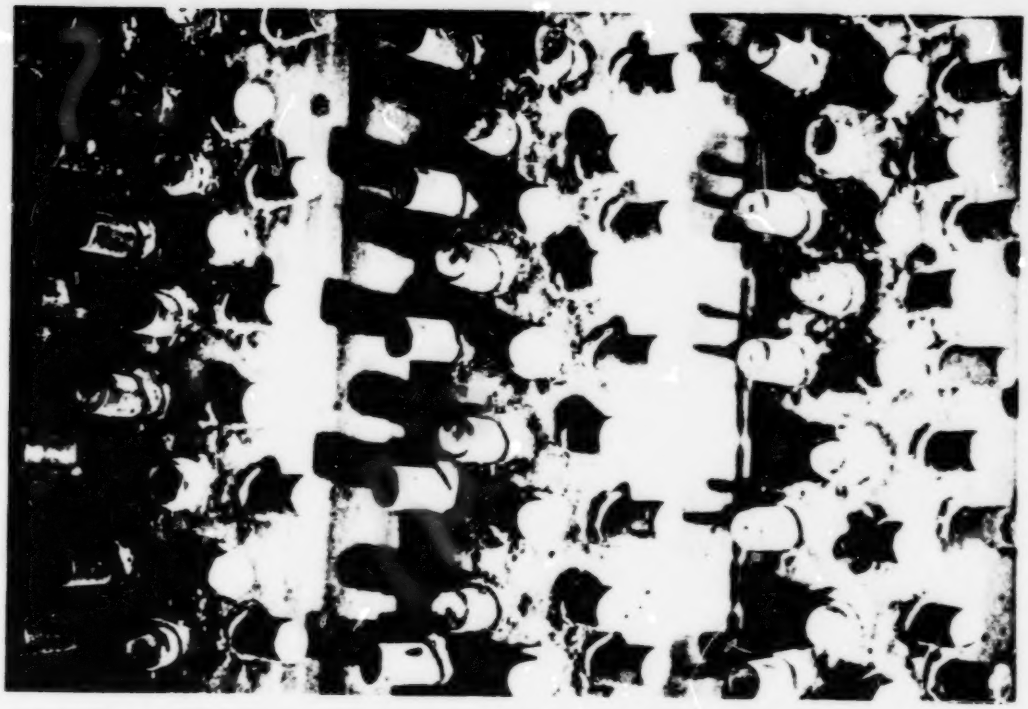
8. February 1985. Sheds and tubes in the area of tube failure. (VR:10)



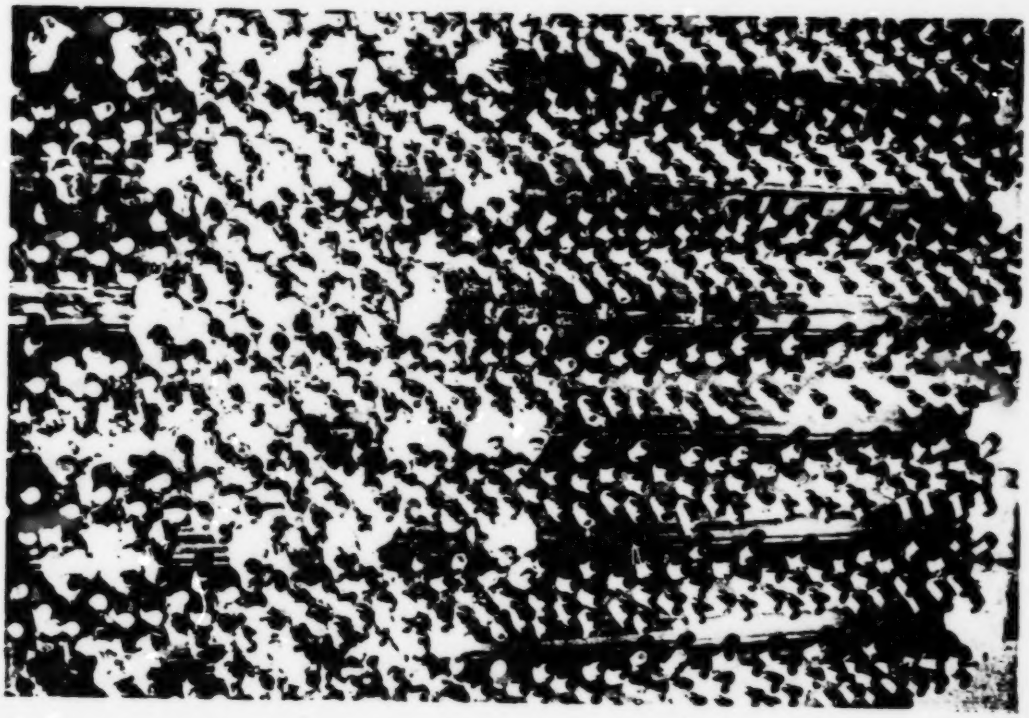
10. September 1985. New studs on waterwalls.
(VR:13)



9. Tube failure with metal removed. (VR:10a)

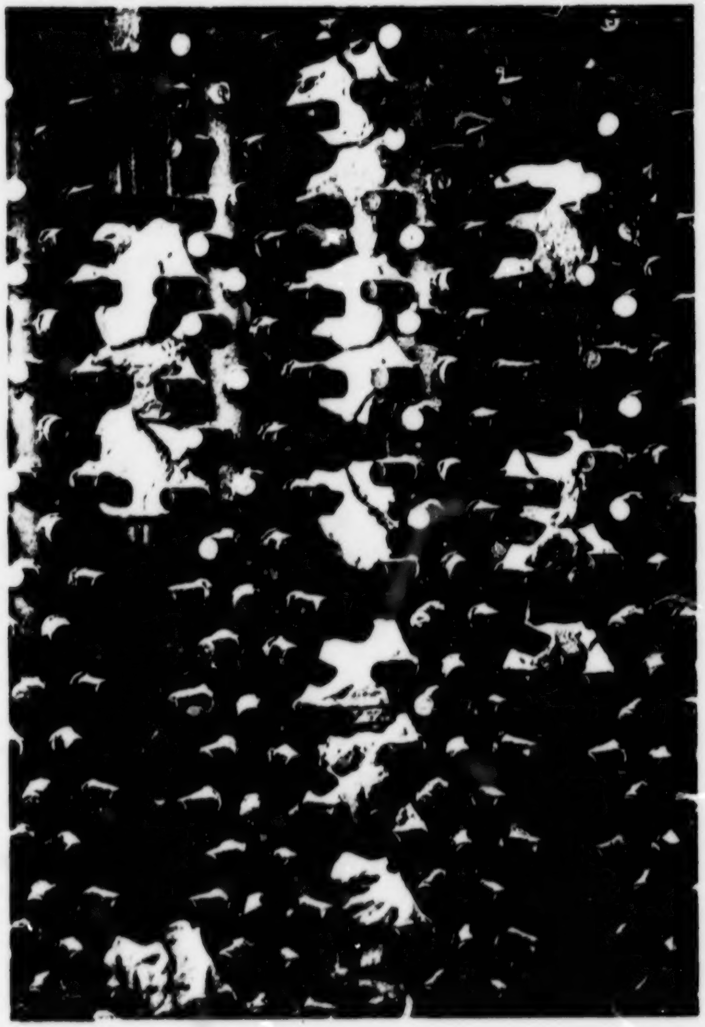


11. September 1985. Closer view of studs on waterwalls. (VR:14)

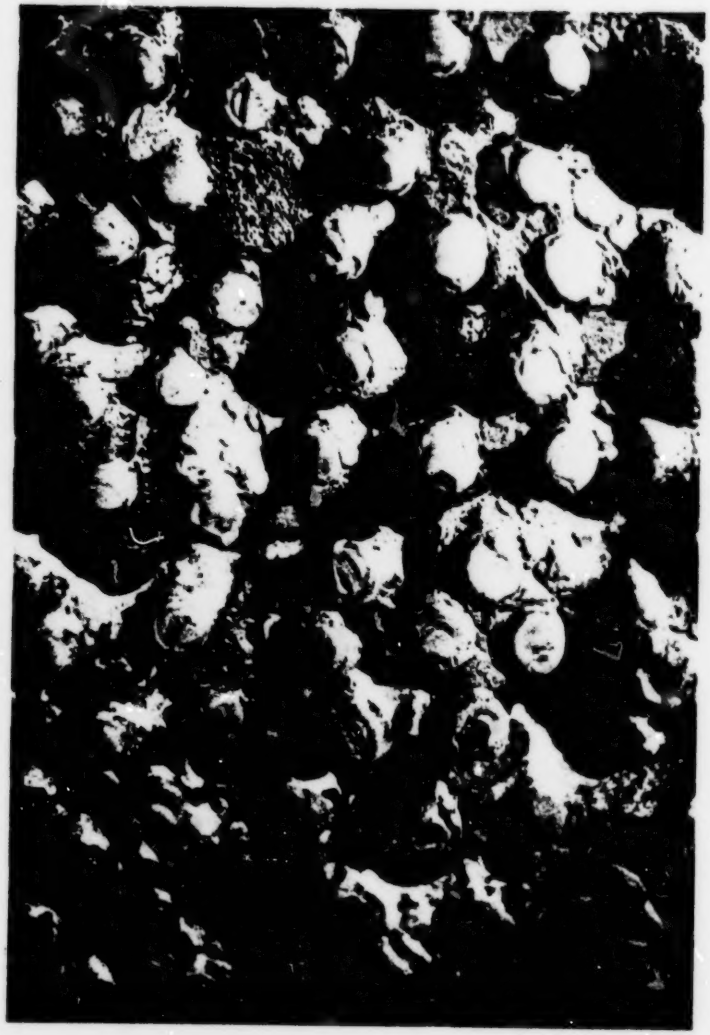


12. January 1986. Studs on waterwalls showing trapped ash after 2500 hours of operation. (VR:16)

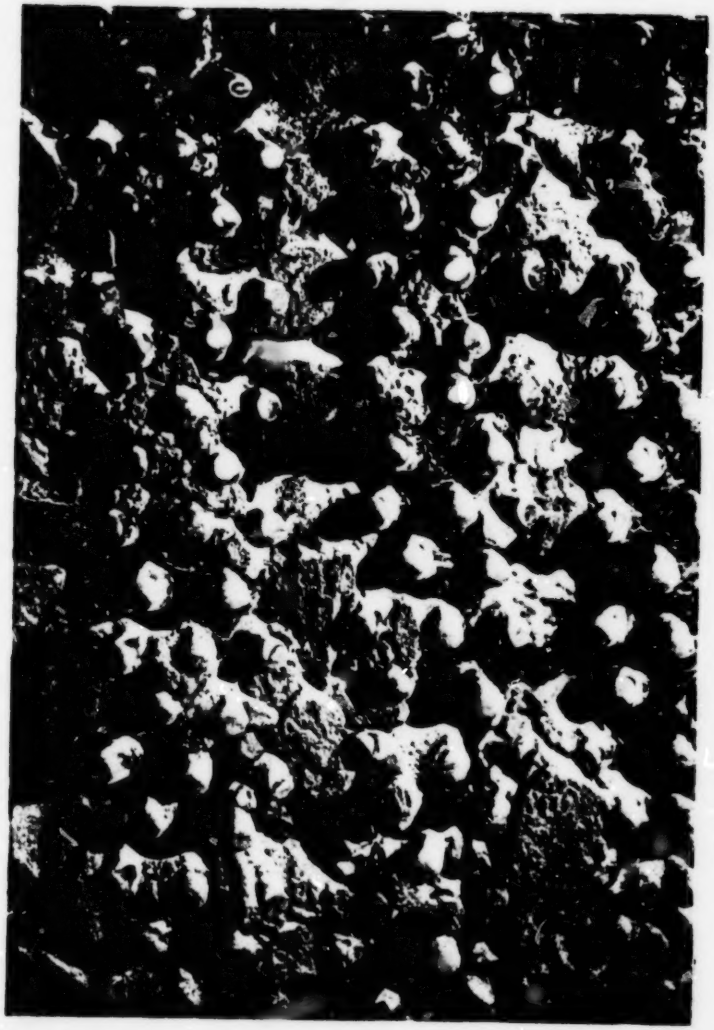
14. January 1986. Studs on waterwalls, closer view, showing some rounding on the free ends of the studs. (VR:20)



13. January 1986. Closer view of studs on waterwalls, cleaner area. (VR:17)

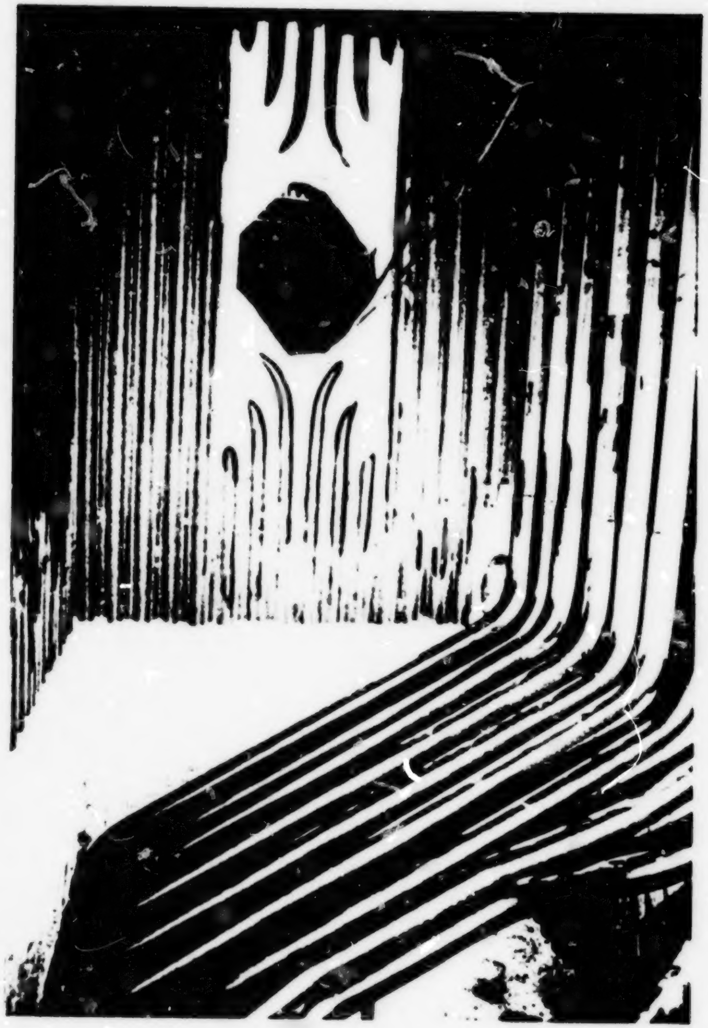


16. January 1986. Studs on waterwalls, closer view showing caps of deposit. (VR:23)

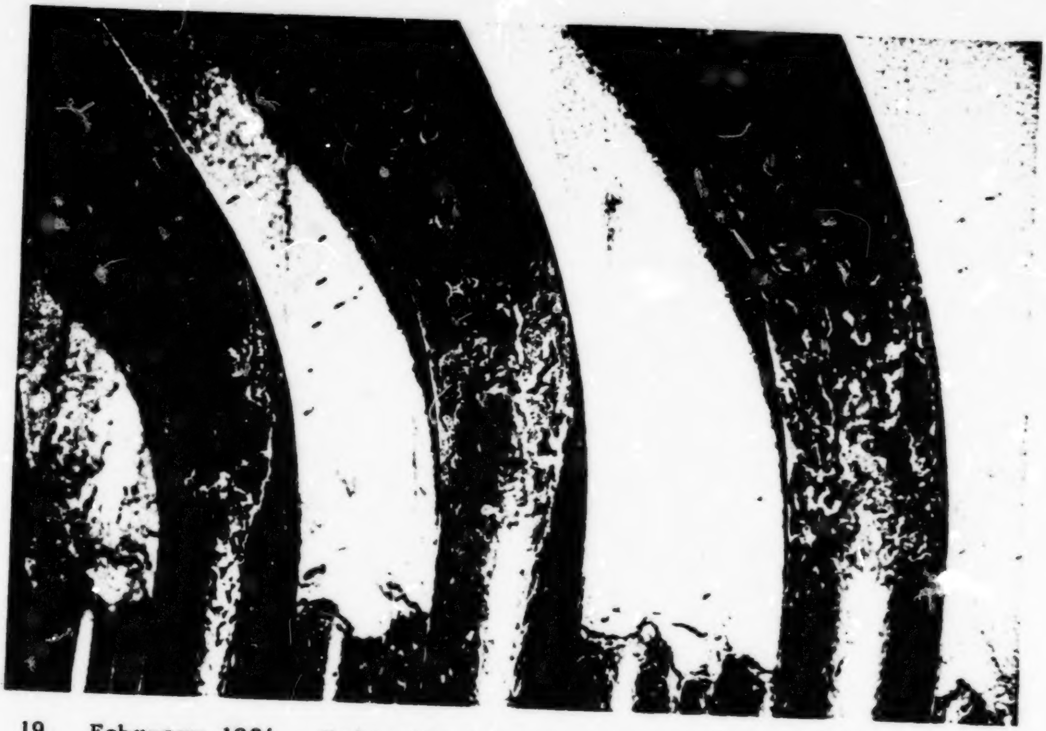


15. January 1986. Studs on waterwalls, general view, showing heavy deposit. (VR:22)

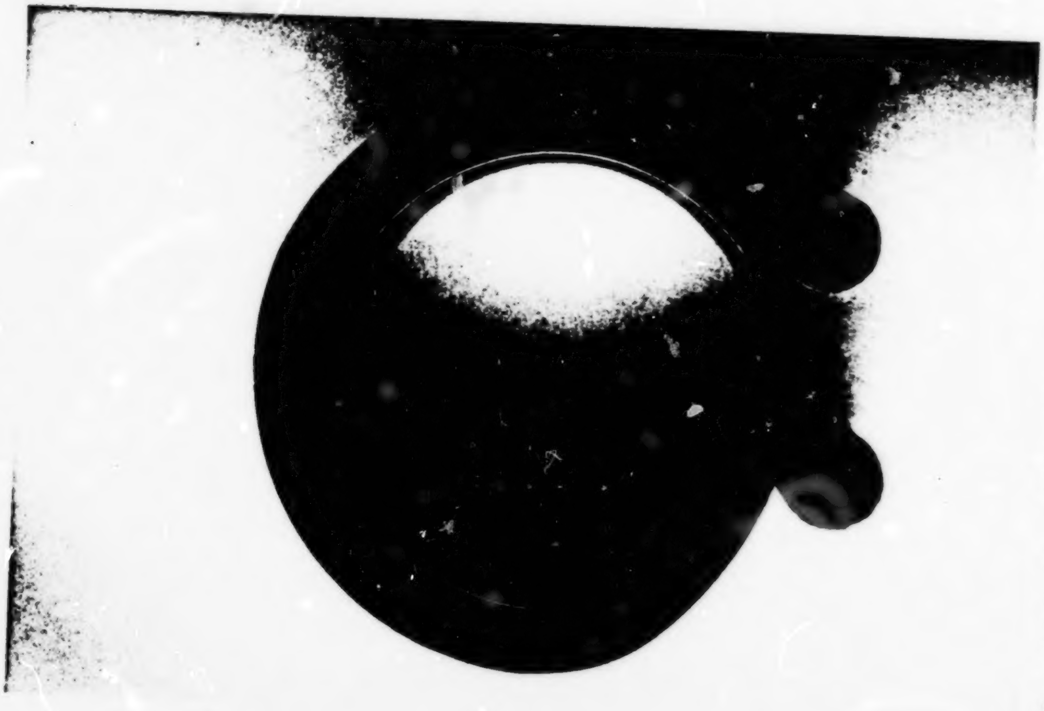
18. February 1984. Top of in-bed tube showing spalling of alonized layer. (VR:25)



17. June 1983. In-bed tubes after installation of refractory. (VR:24)

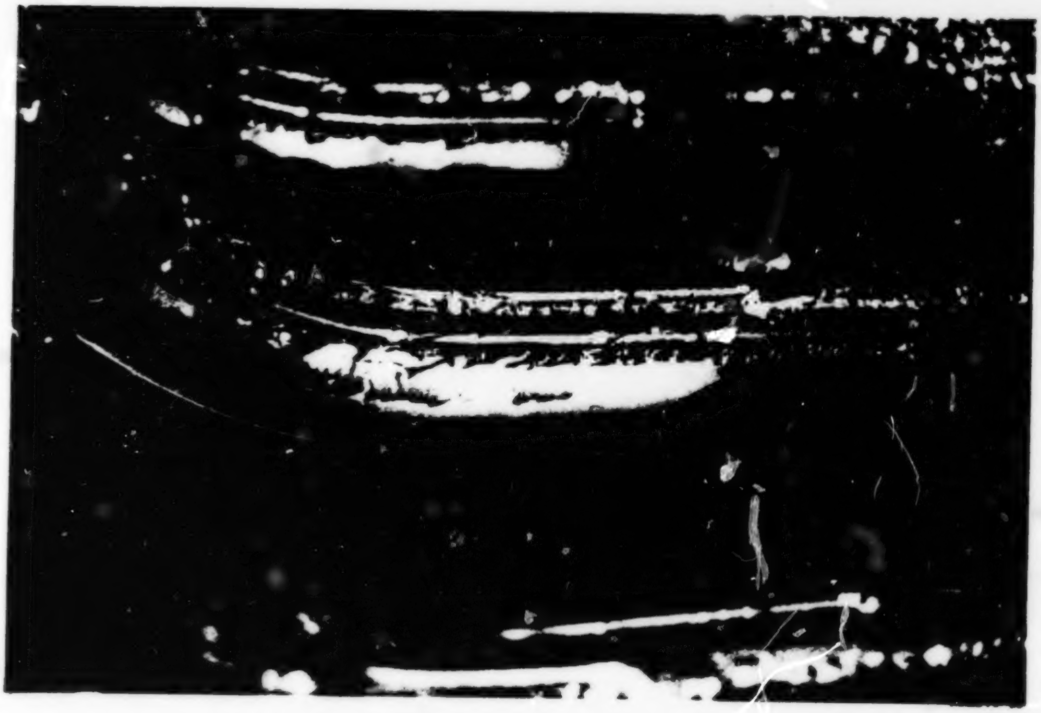


19. February 1984. Underside of in-bed tubes showing loss of alonizing.
(VR:26)



20. September 1985. Cross-section of eroded in-bed tube.
(VR:30)

21. January 1986. Top view of in-bed tube; no polishing after 1500 hours of operation. (VR:31)

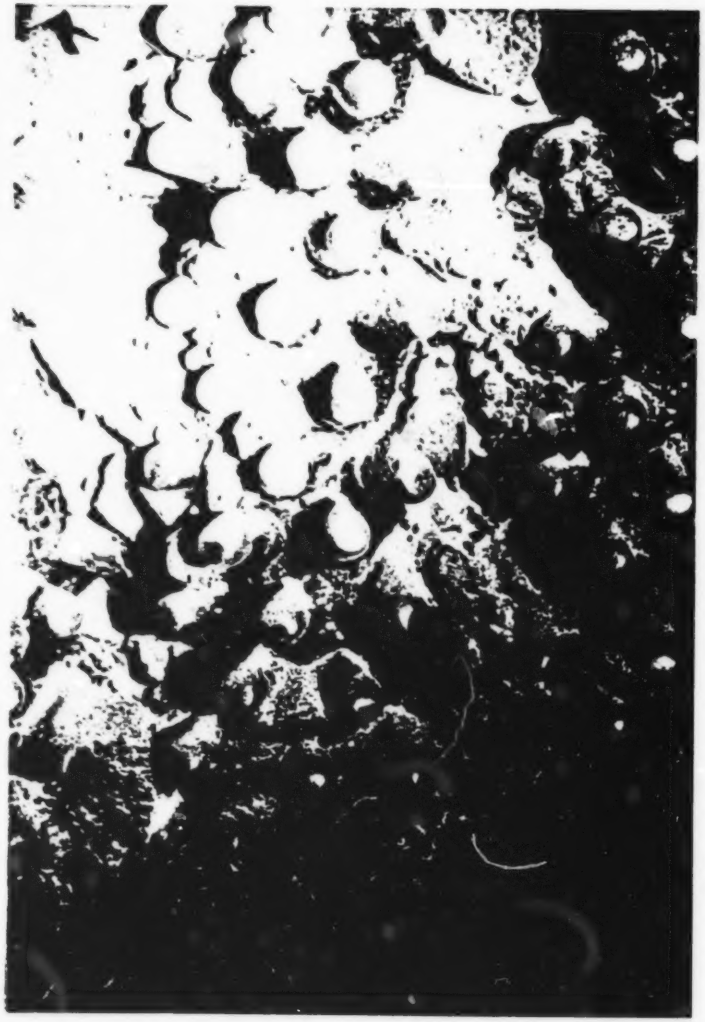


22. January 1986. In-bed tubes; some polishing on rods. (VR:32)

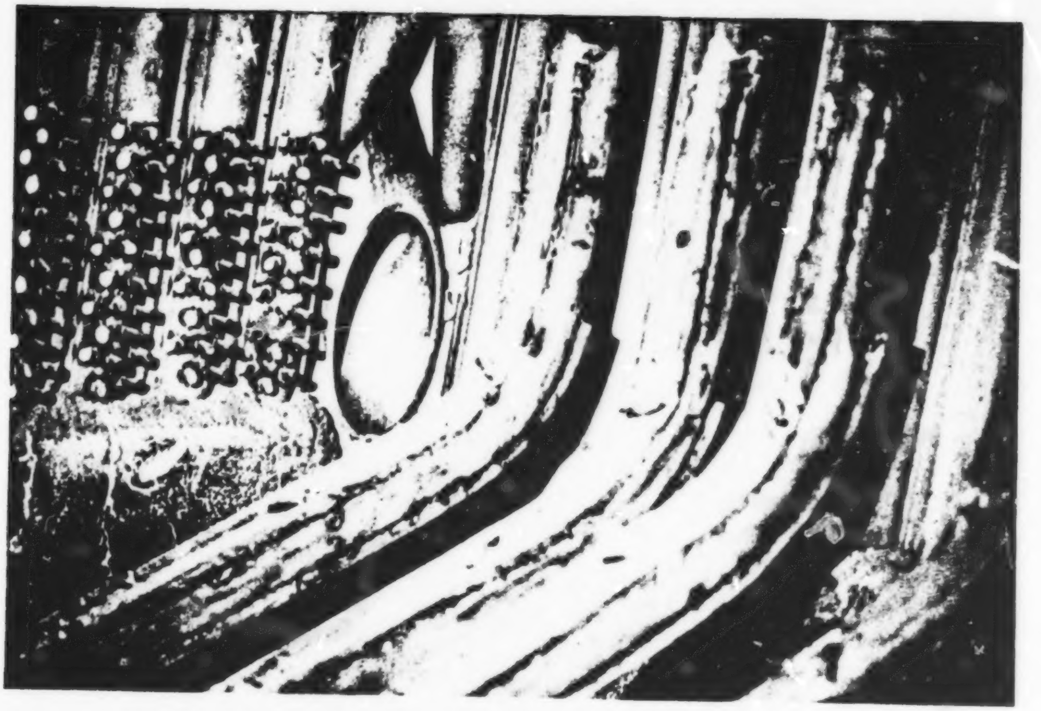
24. May 1986. View in Bed A following 4200 hours of operation after studding the water wall tubes. (VR:34a)

23. January 1986. Underside of lower bend of in-bed tube, showing some polishing on rods. (VR:34)

26. May 1986. View in Bed B following 2500 hours of operation after studding and rodding. (VR: 34e)

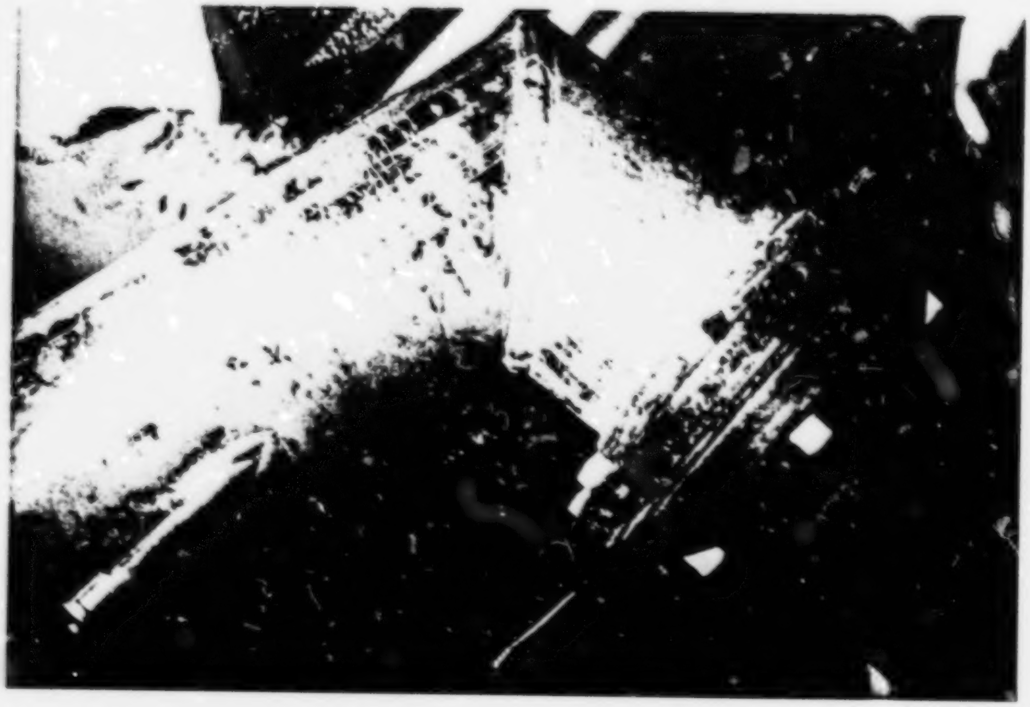


25. May 1986. Waterwall studs showing heavy deposit and rounding. (VR: 34c)



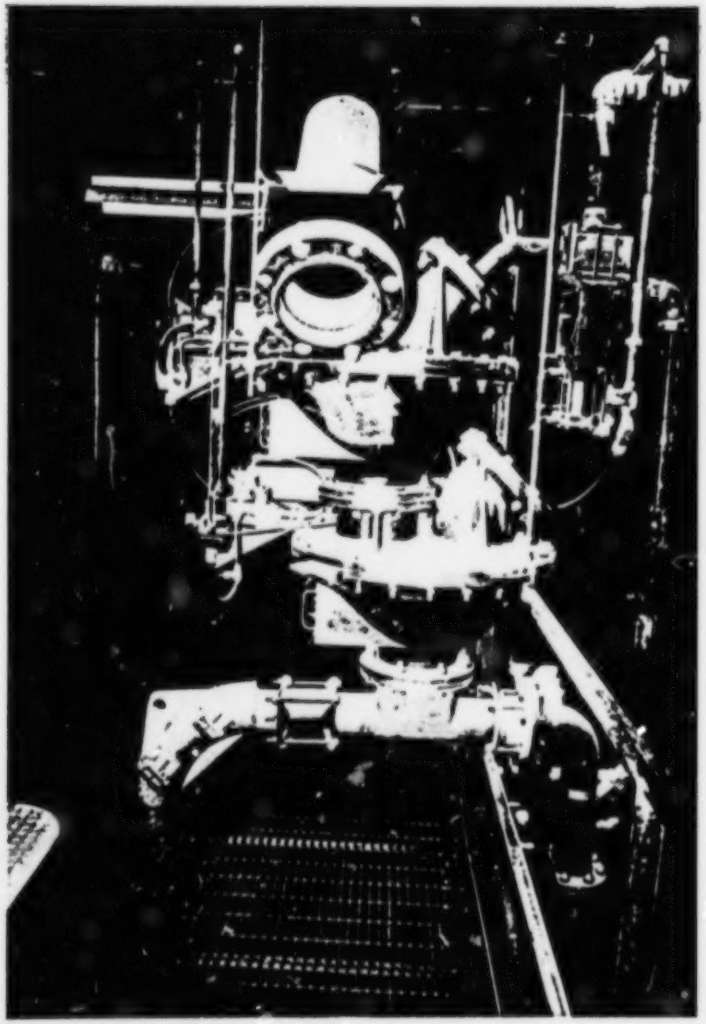
27. May 1986. In-bed tubes and limestones feed point. (VR:35)

28. Summer 1985. Lower elbow of z-section of the modified fly ash reinjection system installed. (VR:38)



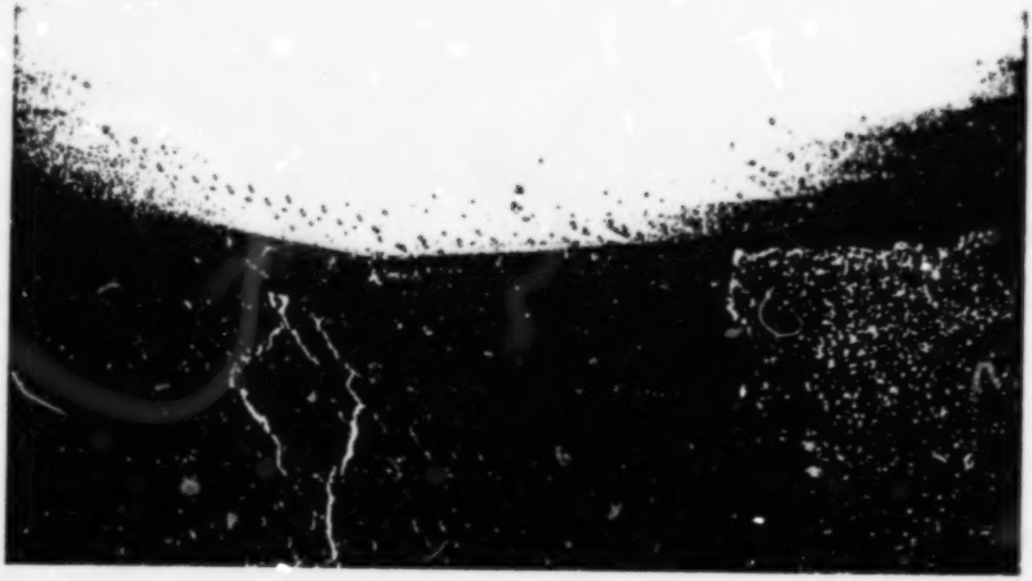
29. Summer 1985. Upper elbow of z-section of modified fly ash reinjection system installed. (VR:39)

30. Connection to furnace wall; air nozzle of the modified fly ash reinjection system. (VR:40)

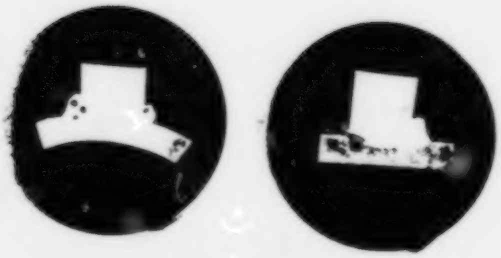


32. 1984. Permalok reinjection system for cyclone ash. (VR:43)

31. Reinjection port showing air nozzle. (VR:42)



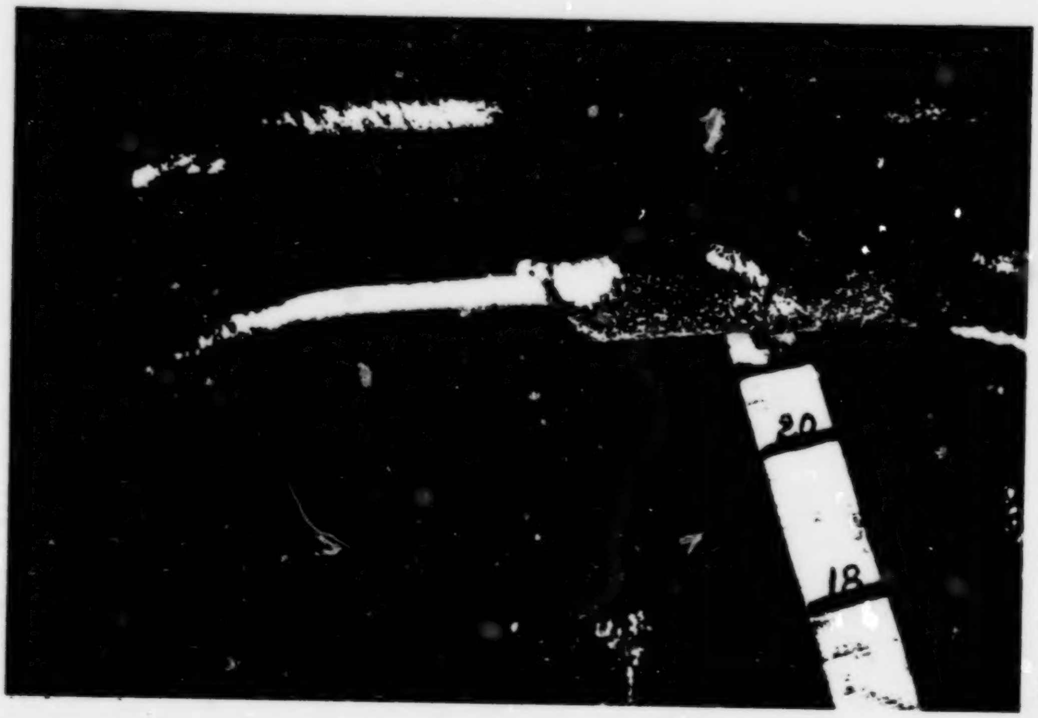
33. Early 1985. Typical bulging of Lavalox. Some of it had to be replaced within one year of installation. (VR:44)



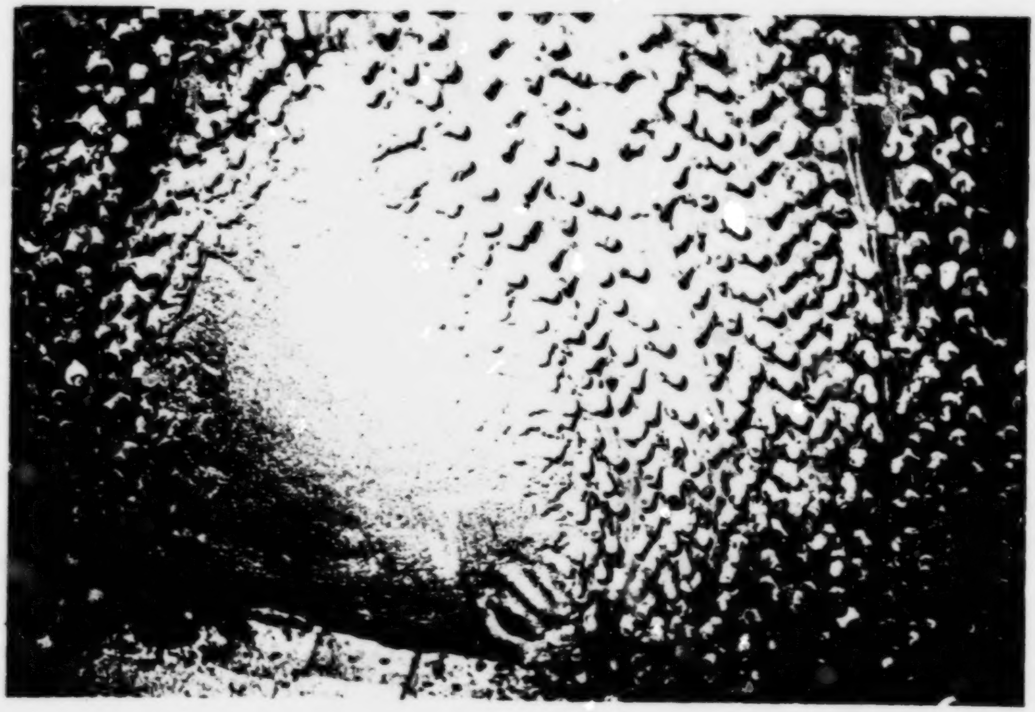
34. September 1985. Section of studs showing weld penetration. (VR:52)

36. Interbed transfer gate, as installed, and the unprotected tubes it slides against. (VR:56)

35. September 1985. Bed A after installation of additional bubble caps and heavy sleeve on thermocouple well. (VR:53)

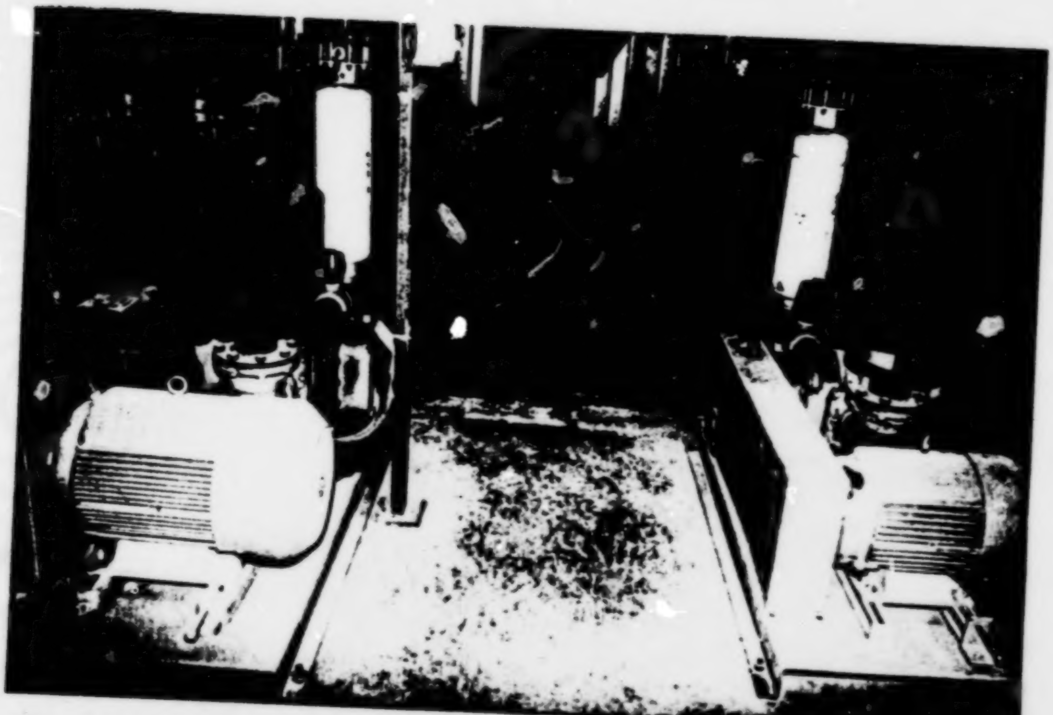


37. Interbed transfer gate, as installed, shown jammed partly open. (VR:57)



38. September 1985. FBB-2. First version of interbed transfer opening which proved too small. (VR:59)

39. September 1985. FBB-2. Second and successful interbed transfer opening. (VR:60)



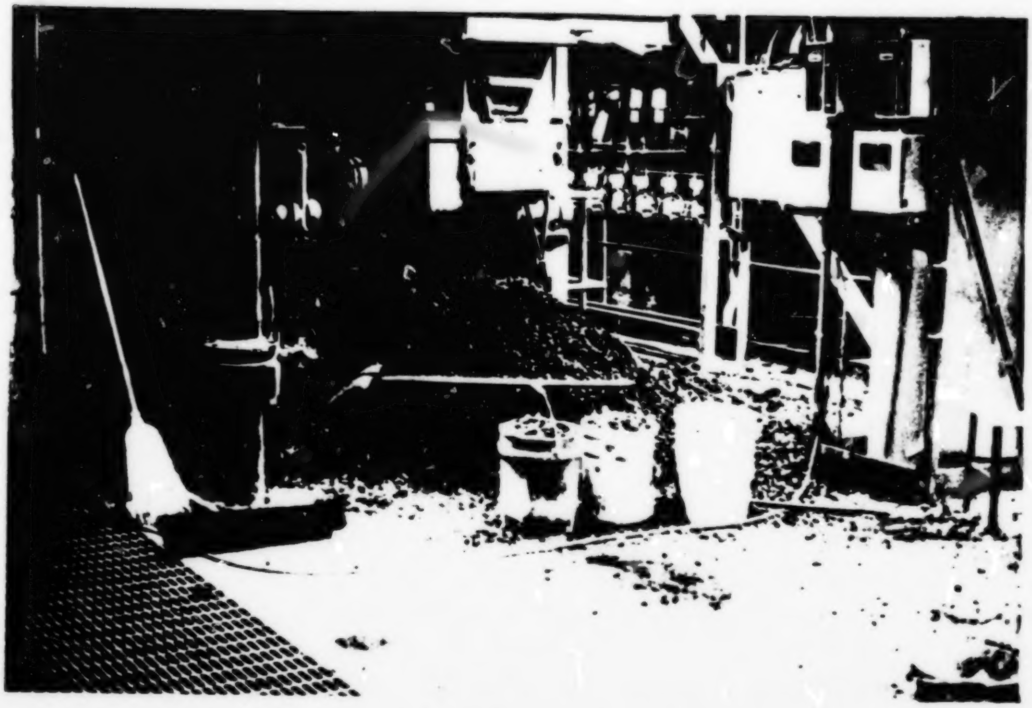
40. Reinjection blowers as installed. They were noisy and had to be enclosed. One is now rendered redundant by the new reinjection system.
(VR:68)

41. View of spreader stokers on front of boiler. (VR:69)

42. FBB-1. Edge view of distributor at hatch into windbox. This is the area that was not sealed perfectly on one occasion, resulting in air leakage from the windbox across the distributor, which eroded a hole in the distributor. (VR:70)

44. Example of erosion caused by a bubble cap pointed at an air nozzle on the periphery of the bed. (VR:72)

43. FBB-1. Hole in distributor plate which resulted from the leakage described in picture No. 42. (VR:71)



45. Firing floor in front of boiler when trying to cope with wet coal. Spreader stoker pans had to be removed to prevent jamming. This resulted in the coal piling up on the floor. (VR:78)

APPENDIX I

TYPICAL ANALYSES OF COALS USED IN THE FBB PLANT AT CANADIAN FORCES BASE IN SUMMERSIDE, PRINCE EDWARD ISLAND

The enclosed Tables give typical Proximate and Ultimate analyses of the various coals used in the FBB Plant at CFB Summerside, P.E.I.

AFBC at SUMMERSIDE
COAL ULTIMATE ANALYSIS

% H2O as REC'D: 7.95　　DATE: NOV 24 1983
LOAD: 100% MCR　　COAL: PRINCE DEVCO
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS						
	% H2O	% C	% H	% N	% ASH	% S	% O(diff)
831124-C-09/12	6.02	63.30	4.18	1.15	13.12	5.25	6.98
831124-C-13/16	6.37	66.23	4.17	1.15	10.75	4.18	7.15
831124-C-17/20	5.36	67.39	4.39	1.14	10.96	4.18	6.58
831124-C-21/24	5.67	64.68	4.24	1.08	12.88	4.72	6.73
831125-C-01/04	5.48	61.75	4.08	1.02	17.07	4.44	6.16
841125-C-05/08	5.45	61.89	3.99	1.13	15.32	4.24	7.98
MEAN	5.73	64.21	4.17	1.11	13.35	4.50	6.93
STD. DEV.	.39	2.31	.14	.05	2.47	.42	.62
as REC'D BASIS	7.95	62.78	4.08	1.09	13.05	4.40	6.78

AFBC at SUMMERSIDE
COAL PROXIMATE ANALYSIS

% H2O as REC'D: 7.95 DATE: NOV 24 1983
LOAD: 100% MCR COAL: PRINCE DEVCO
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS					
	% H2O	% VOL MATTER	% ASH	% FIXED CARBON	% S	BTU /lb
831124-C-09/12	0.00	33.94	13.96	52.10	0.00	12109.00
831124-C-13/16	0.00	35.20	11.48	53.32	0.00	12466.00
831124-C-17/20	0.00	35.30	11.58	53.12	0.00	12537.00
831124-C-21/24	0.00	34.73	13.65	51.62	0.00	12231.00
831125-C-01/04	0.00	32.58	18.06	49.36	0.00	11484.00
831125-C-05/08	0.00	32.71	16.20	51.09	0.00	11919.00
MEAN	0.00	34.08	14.16	51.77	0.00	12124.67
STD. DEV.	0.00	1.21	2.59	1.46	0.00	387.87
as REC'D BASIS	7.95	31.37	13.03	47.65	0.00	11160.76

AFBC at SUMMERSIDE
COAL PROXIMATE ANALYSIS

% H2O as REC'D: 9.89 DATE: NOV 26 1983
LOAD: 65% MCR COAL: PRINCE DEVCO
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS					
	% H2O	% VOL MATTER	% ASH	% FIXED CARBON	% S	BTU /lb
831125-C-18/21	0.00	34.28	12.81	52.91	0.00	12423.00
831126-C-22/01	0.00	34.29	13.08	52.63	0.00	12191.00
831126-C-02/05	0.00	33.00	15.16	51.84	0.00	11758.00
MEAN	0.00	33.86	13.68	52.46	0.00	12124.00
STD. DEV.	0.00	.74	1.29	.55	0.00	337.52
as REC'D BASIS	9.89	30.51	12.33	47.27	0.00	10924.94

AFBC at SUMMERSIDE
COAL ULTIMATE ANALYSIS

% H2O as REC'D: 9.89　　DATE: NOV 26 1983
LOAD: 65% MCR　　COAL: PRINCE DEVCO
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS						
	% H2O	% C	% H	% N	% ASH	% S	% O(diff)
831125-C-18/21	5.93	64.66	4.02	1.10	12.05	4.53	7.71
831126-C-22/01	6.28	63.90	4.04	1.11	12.26	4.78	7.63
831126-C-02/05	6.68	62.22	3.92	1.07	14.15	5.01	6.95
MEAN	6.30	63.59	3.99	1.09	12.82	4.77	7.43
STD. DEV.	.38	1.25	.06	.02	1.16	.24	.42
as REC'D BASIS	9.89	61.31	3.85	1.05	12.36	4.60	7.16

AFBC at SUMMERSIDE
COAL ULTIMATE ANALYSIS

% H2O as REC'D: 8.44 DATE: FEB 23 1984
LOAD: 65% MCR COAL: BROGAN
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS						
	% H2O	% C	% H	% N	% ASH	% S	% O(diff)
840223-C-13/14	1.78	67.58	4.09	1.27	9.42	4.76	11.10
840223-C-15/16	1.97	68.18	4.36	1.20	10.20	5.49	8.60
840223-C-18/19	1.71	68.40	4.13	1.28	10.01	5.81	8.66
840223-C-20/21	1.76	68.01	4.25	1.26	10.34	6.12	8.26
MEAN	1.80	68.04	4.21	1.25	9.99	5.55	9.15
STD. DEV.	.11	.35	.12	.04	.40	.58	1.31
as REC'D BASIS	8.44	63.53	3.93	1.17	9.33	5.18	8.55

AFBC at SUMMERSIDE
COAL PROXIMATE ANALYSIS

% H20 as REC'D: 8.44 DATE: FEB 23 1984
LOAD: 65% MCR COAL: BROGAN
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS					
	% H20	% VOL MATTER	% ASH	% FIXED CARBON	% S	BTU /lb
840223-C-13/14	0.00	35.38	9.59	55.03	4.85	12714.00
810223-C-15/16	0.00	36.10	10.40	53.50	5.60	12522.00
840223-C-18/19	0.00	35.14	10.18	54.68	5.91	12605.00
840223-C-20/21	0.00	35.65	10.53	53.82	6.23	12431.00
MEAN	0.00	35.57	10.18	54.26	5.65	12568.00
STD. DEV.	0.00	.41	.42	.72	.59	120.51
as REC'D BASIS	8.44	32.57	9.32	49.68	5.17	11507.26

AFBC at SUMMERSIDE
COAL ULTIMATE ANALYSIS

% H2O as REC'D: 7.95
LOAD: 100% MCR
LIMESTONE: HAVELOCK

DATE: FEB 25 1984
COAL: BROGAN

SAMPLE ID	COAL ANALYSIS						
	% H2O	% C	% H	% N	% ASH	% S	% O(diff)
840225-C-06/07	2.08	65.23	4.47	1.17	10.95	5.74	10.36
840225-C-08/10	2.09	69.57	4.52	1.24	9.37	4.93	8.28
840225-C-11/12	1.85	69.41	4.19	1.22	9.38	5.31	8.64
840225-C-13/14	2.04	70.14	4.79	1.19	9.06	5.09	7.69
840225-C-15/16	1.76	70.01	4.34	1.20	9.38	4.52	8.79
MEAN	1.96	68.87	4.46	1.20	9.63	5.12	8.75
STD. DEV.	.15	2.06	.22	.03	.75	.45	.99
as REC'D BASIS	7.95	64.75	4.19	1.13	9.05	4.81	8.23

AFBC at SUMMERSIDE
COAL PROXIMATE ANALYSIS

% H2O as REC'D: 7.95
LOAD: 100% MCR
LIMESTONE: HAVELOCK
DATE: FEB 25 1984
COAL: BROGAN

SAMPLE ID	COAL ANALYSIS					
	% H2O	% VOL MATTER	% ASH	% FIXED CARBON	% S	BTU /lb
840225-C-06/07	0.00	35.18	11.18	53.64	5.86	12333.00
840225-C-08/10	0.00	35.70	9.57	54.73	5.04	12780.00
840225-C-11/12	0.00	35.38	9.56	55.06	5.41	12776.00
840225-C-13/14	0.00	35.37	9.25	55.38	5.20	12817.00
840225-C-15/16	0.00	35.33	9.55	55.12	4.60	12781.00
MEAN	0.00	35.39	9.82	54.79	5.22	12697.40
STD. DEV.	0.00	.19	.77	.68	.46	204.38
as REC'D BASIS	7.95	32.58	9.04	50.43	4.81	11687.96

AFBC at SUMMERSIDE
COAL ULTIMATE ANALYSIS

% H2O as REC'D: 9.8　　DATE: MAR 22 1984
LOAD: 65% MCR　　COAL: EVANS
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS						
	% H2O	% C	% H	% N	% ASH	% S	% O(diff)
840322-C-07/09	1.38	67.51	4.04	1.00	11.24	6.15	8.68
840322-C-10/12	1.48	67.89	4.09	1.15	11.06	6.70	7.63
840322-C-13/15	1.51	68.35	3.94	1.18	10.09	6.04	8.89
840322-C-16/19	1.48	68.35	4.11	1.13	9.77	5.36	9.80
MEAN	1.46	68.03	4.05	1.12	10.54	6.06	8.75
STD. DEV.	.06	.41	.08	.08	.72	.55	.89
as REC'D BASIS	9.80	62.35	3.71	1.02	9.66	5.56	8.02

AFBC at SUMMERSIDE
COAL PROXIMATE ANALYSIS

% H2O as REC'D: 9.8
DATE: MAR 22 1984
LOAD: 65% MCR
COAL: EVANS
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS					
	% H2O	% VOL MATTER	% ASH	% FIXED CARBON	% S	BTU /lb
840322-C-07/09	0.00	34.47	11.40	54.13	6.24	12298.00
840322-C-10/12	0.00	34.47	11.23	54.30	6.80	12235.00
840322-C-13/15	0.00	34.12	10.24	55.64	6.13	12309.00
840322-C-16/19	0.00	35.02	9.92	55.06	5.44	12512.00
MEAN	0.00	34.52	10.70	54.78	6.15	12338.50
STD. DEV.	0.00	.37	.73	.70	.56	120.17
as REC'D BASIS	9.80	31.14	9.65	49.41	5.55	11129.33

AFBC at SUMMERSIDE
COAL ULTIMATE ANALYSIS

% H2O as REC'D: 7.07 DATE: APR 14 1984
LOAD: 100% MCR COAL: EVANS
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS						
	% H2O	% C	% H	% N	% ASH	% S	% O(diff)
840414-C-06/07	1.46	65.80	5.28	1.08	10.57	5.83	9.98
840414-C-08/09	1.48	66.76	4.20	1.11	9.83	6.73	9.89
840414-C-10/11	1.59	65.40	3.96	1.21	11.57	6.27	10.00
840414-C-12/13	1.67	67.83	4.22	1.21	9.82	6.78	8.47
840414-C-14/15	1.33	65.67	3.94	1.18	10.11	6.40	11.37
840414-C-16/18	1.58	63.74	3.78	1.19	11.32	6.87	11.52
MEAN	1.52	65.87	4.23	1.16	10.54	6.48	10.21
STD. DEV.	.12	1.37	.54	.06	.76	.39	1.12
as REC'D BASIS	7.07	62.21	4.00	1.10	9.95	6.12	9.64

AFBC at SUMMERSIDE
COAL PROXIMATE ANALYSIS

% H2O as REC'D: 7.07   DATE: APR 14 1984
LOAD: 100% MCR   COAL: EVANS
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS					
	% H2O	% VOL MATTER	% ASH	% FIXED CARBON	% S	BTU /lb
840414-C-06/07	0.00	33.67	10.73	55.60	5.92	12162.00
840414-C-08/09	0.00	35.59	9.98	54.43	6.83	12504.00
840414-C-10/11	0.00	33.89	11.76	54.35	6.37	12024.00
840414-C-12/13	0.00	35.52	9.99	54.49	6.90	12565.00
840414-C-14/15	0.00	34.78	10.25	54.97	6.49	12410.00
840414-C-16/18	0.00	35.28	11.50	53.22	6.98	12387.00
MEAN	0.00	34.79	10.70	54.51	6.58	12342.00
STD. DEV.	0.00	.83	.77	.79	.40	207.92
as REC'D BASIS	7.07	32.33	9.95	50.66	6.12	11469.42

AFBC at SUMMERSIDE
COAL PROXIMATE ANALYSIS

% H2O as REC'D: 3.78 DATE: JAN 22 1985
LOAD: 100% MCR COAL: MINTO
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS					
	% H2O	% VOL MATTER	% ASH	% FIXED CARBON	% S	BTU /lb
850122-C-09/10	0.00	33.09	19.29	47.62	7.29	12084.00
850122-C-11/12	0.00	35.30	16.08	48.62	7.37	12748.00
850122-C-13/14	0.00	34.74	15.78	49.48	7.26	12754.00
850122-C-15/16	0.00	34.19	17.27	48.54	8.49	12437.00
850122-C-17/18	0.00	33.21	19.92	46.87	7.54	11975.00
850122-C-19/20	0.00	34.09	18.44	47.47	8.05	12224.00
MEAN	0.00	34.10	17.80	48.10	7.67	12370.33
STD. DEV.	0.00	.86	1.70	.95	.50	332.86
as REC'D BASIS	3.78	32.81	17.12	46.28	7.38	11902.73

AFBC at SUMMERSIDE
COAL ULTIMATE ANALYSIS

% H20 as REC'D: 3.78 DATE: JAN 22 1985
LOAD: 100% MCR COAL: MINTO
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS						
	% H20	% C	% H	% N	% ASH	% S	% O(diff)
850122-C-09/10	.60	64.78	4.30	.84	19.17	7.25	3.06
850122-C-11/12	.61	68.18	4.76	.95	15.98	7.33	2.19
850122-C-13/14	.49	67.99	4.52	.91	15.70	7.22	3.17
850122-C-15/16	.46	65.06	4.11	.89	17.19	8.45	3.84
850122-C-17/18	.63	64.02	4.45	.89	19.79	7.49	2.73
850122-C-19/20	.71	65.13	4.40	.89	18.31	7.99	2.57
MEAN	.58	65.86	4.42	.90	17.69	7.62	2.93
STD. DEV.	.09	1.77	.22	.04	1.68	.49	.57
as REC'D BASIS	3.78	63.75	4.28	.87	17.12	7.38	2.83

AFBC at SUMMERSIDE
COAL PROXIMATE ANALYSIS

% H2O as REC'D: 10.08 DATE: JAN 23 1985
LOAD: 100% MCR COAL: NOVACO
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS					
	% H2O	% VOL MATTER	% ASH	% FIXED CARBON	% S	BTU /lb
850123-C-09/10	0.00	32.48	18.85	46.67	4.78	11509.00
850123-C-11/12	0.00	32.95	22.96	44.09	5.11	10600.00
850123-C-13/14	0.00	32.82	22.80	44.38	5.21	10677.00
850123-C-15/16	0.00	31.14	24.76	44.10	5.43	10168.00
850123-C-17/19	0.00	33.10	21.07	45.83	5.15	10924.00
MEAN	0.00	32.50	22.09	45.01	5.14	10775.60
STD. DEV.	0.00	.79	2.23	1.17	.23	492.35
as REC'D BASIS	10.08	29.22	19.86	40.48	4.62	9689.42

AFBC at SUMMERSIDE
COAL ULTIMATE ANALYSIS

% H2O as REC'D: 10.08 DATE: JAN 23 1985
LOAD: 100% MCR COAL: NOVACO
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS						
	% H2O	% C	% H	% N	% ASH	% S	% O(diff)
850123-C-09/10	1.48	62.76	4.33	1.24	18.57	4.71	6.91
850123-C-11/12	1.15	58.72	4.22	1.12	22.70	5.05	7.04
850123-C-13/14	1.52	58.09	4.21	1.14	22.45	5.13	7.46
850123-C-15/16	.93	55.18	3.70	1.08	24.53	5.38	9.20
850123-C-17/19	2.35	59.52	3.84	1.14	20.57	5.03	7.55
MEAN	1.49	58.85	4.06	1.14	21.76	5.06	7.63
STD. DEV.	.54	2.73	.27	.06	2.27	.24	.92
as REC'D BASIS	10.08	53.80	3.71	1.05	19.89	4.63	6.98

AFBC at SUMMERSIDE
COAL PROXIMATE ANALYSIS

% H2O as REC'D: 10.02 DATE: JAN 24 1985
LOAD: 65% MCR COAL: NOVACO
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS					
	% H2O	% VOL MATTER	% ASH	% FIXED CARBON	% S	BTU /lb
850124-C-08/09	0.00	35.53	15.00	49.47	4.29	11931.00
850124-C-10/11	0.00	33.13	19.01	47.86	5.07	10989.00
850124-C-12/13	0.00	33.61	18.15	48.24	4.74	11226.00
850124-C-14/16	0.00	34.55	16.43	49.02	4.92	11653.00
850124-C-17/19	0.00	34.47	16.30	49.23	4.45	11612.00
MEAN	0.00	34.26	16.98	48.76	4.69	11482.20
STD. DEV.	0.00	.93	1.59	.68	.32	372.94
as REC'D BASIS	10.02	30.83	15.28	43.88	4.22	10331.68

AFBC at SUMMERSIDE
COAL ULTIMATE ANALYSIS

% H2O as REC'D: 10.02 DATE: JAN 24 1985
LOAD: 65% MCR COAL: NOVACO
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS						
	% H2O	% C	% H	% N	% ASH	% S	% O(diff)
850124-C-08/09	1.88	64.94	4.35	1.28	14.72	4.21	8.62
850124-C-10/11	.70	60.74	4.15	1.16	18.88	5.03	9.34
850124-C-12/13	.82	61.50	4.17	1.21	18.00	4.70	9.60
850124-C-14/16	1.00	63.93	4.43	1.27	16.27	4.87	8.23
850124-C-17/19	.90	63.90	4.34	1.27	16.15	4.41	9.03
MEAN	1.06	63.00	4.29	1.24	16.80	4.64	8.96
STD. DEV.	.47	1.79	.12	.05	1.64	.33	.55
as REC'D BASIS	10.02	57.36	3.90	1.13	15.30	4.23	8.16

AFBC at SUMMERSIDE
COAL PROXIMATE ANALYSIS

% H2O as REC'D: 7.07 DATE: JAN 25 1985
LOAD: 65% MCR COAL: MINTO
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS					
	% H2O	% VOL MATTER	% ASH	% FIXED CARBON	% S	BTU /lb
850125-C-08/09	0.00	32.15	20.82	47.03	7.10	11669.00
850125-C-10/11	0.00	32.85	19.84	47.31	8.10	11791.00
850125-C-12/13	0.00	33.30	18.34	48.36	6.46	12144.00
850125-C-14/15	0.00	34.38	16.54	49.08	7.44	12538.00
850125-C-16/17	0.00	34.39	18.10	47.51	7.80	12271.00
850125-C-18/19	0.00	35.31	15.89	48.80	6.93	12722.00
MEAN	0.00	33.73	18.25	48.01	7.31	12189.17
STD. DEV.	0.00	1.17	1.88	.85	.60	410.72
as REC'D BASIS	7.07	31.35	16.96	44.62	6.79	11327.39

AFBC at SUMMERSIDE
COAL ULTIMATE ANALYSIS

% H20 as REC'D: 7.07 DATE: JAN 25 1985
LOAD: % MCR COAL: MINTO
LIMESTONE: HAVELOCK

SAMPLE ID	COAL ANALYSIS						
	% H20	% C	% H	% N	% ASH	% S	% O(diff)
850125-C-08/09	.77	59.15	4.18	.90	20.66	7.05	7.29
850125-C-10/11	.87	61.52	4.12	.88	19.67	8.03	4.91
850125-C-12/13	.82	62.17	4.18	.92	18.19	6.41	7.31
850125-C-14/15	.84	65.39	4.39	.96	16.40	7.38	4.64
850125-C-16/17	.60	64.42	4.22	.91	17.99	7.75	4.11
850125-C-18/19	.72	66.16	4.49	.89	15.78	6.88	5.08
MEAN	.77	63.14	4.26	.91	18.11	7.25	5.56
STD. DEV.	.10	2.66	.14	.03	1.86	.59	1.39
as REC'D BASIS	7.07	59.16	3.99	.85	16.97	6.79	5.21